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THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

NOTICES.

The Institution as a body is not responsible for the statements or opinions expressed in any of its publications.

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Issue of Journal. The Journal appears in four parts per sessional volume, viz. in January, April, July and October. A brochure describing the origin, progress and purposes of the Institution, and comprising also the Memorandum and Articles of Association, the By-Laws and Regulations of the Institution, the Library Catalogue to date (with subject index), and the List of Members, was published in September, 1915, to be followed annually by revisions of the Library Catalogue and List of Members.

Members of all classes are entitled to receive these publications free: for additional copies of the Journal they will be charged at the price of five shillings per part, and of the brochures at the prices stated on the wrappers, varying in proportion to bulk.

Changes of Address. It is particularly requested that members notify the Secretary immediately of any change of address; and members are also requested to advise the Parcel-Post Department as well as the Letter Office, of any temporary change of address, as, unless this is done, parcel-post packets will not be re-addressed; but will be returned to the offices of the Institution in London, thus incurring further expense for postage.

To Authors of Papers. Papers should be written in the third person, and the copy should be carefully corrected by the author before it is presented.

All drawings, diagrams or other illustrations should be sent in a fit state for direct photographic reproduction.

All quotations, technical terms, and localisms should be indicated by means of inverted commas.

Foreign weights, measures, and costs should be given whenever possible; and also their English equivalents.

It is suggested that authors append as complete a bibliography of the subject treated as may be possible.

All papers and notes submitted to the Institution are supposed to be original communications unless distinctly stated to be otherwise, in which case the exact reference to the previous publication should be given.

Communications upon papers read at meetings, notices of personal movements, or other matter for which publication is desired in the next issue of the Journal, should be in the hands of the Editor on or before the last day of December, March, June or September as the case may be. Subsequent delivery may be too late for insertion.

The Council desire to draw the attention of authors to the serious increase in the cost of production. Papers, both for the Journal and for communication to the Institution, should be as concise and condensed as possible.

Communications. The Council invite members to submit papers for the forthcoming session. Communications to the Institution will, subject to the approval of the Publication Committee, be published in the Journal.

Appointments Register. A Register will be kept at the Offices of the Institution for the convenience of firms requiring the services of members and for members requiring appointments, but on the distinct understanding that the Institution accepts no responsibility and gives no guarantee.

Library. The Institution's Library is in course of reorganisation in the new premises at No. 5, John Street, Adelphi, and may be consulted between 11 and 4 daily. Extensive additions are being made to the current and standard literature on Petroleum.

The attention of members is drawn to the new supplement of the Journal which deals with current Petroleum Literature. To make this section of the maximum usefulness it is necessary that there should be full co-operation between chemists, engineers and geologists, and that matter which has inadvertently escaped notice shall be immediately sent in to the Editors. The Institution is indebted to Mr. Andrew Campbell for the compilation of the bibliography.

Advertisements in the Journal. A limited number of Advertisements of firms interested in the Petroleum Industry may be inserted in the Journal. Application for terms, etc., should be made to the Secretary.

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(Members are desired, when making enquiries or placing orders with advertisers, to mention that they have seen their announcement in the Journal.)

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PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that Members of the Institution send information regarding their movements to the Secretary for insertion under this heading.

Mr. R. H. PARNELL left for Burma in June to take up his duties as Assistant Fields Superintending Engineer.

The Institution is indebted to Mr. GEORGE HOWELL, F.G.S., for the able help he is giving in connection with the re-organisation of the Library.

Mr. T. DEWHURST, geologist, is at home on leave from Burma.

Mr. C. B. ROSENPLAENTER returned from Trinidad early in June.

The Council gratefully acknowledge the receipt of 43 Slides in connection with Petroleum Refining from Mr. ANDREW CAMPBELL, and 10 from Mr. ALFRED I. WILSON, in connection with Diesel Engines.

The Lord President, as President of the Committee of Council for Scientific and Industrial Research, has appointed Dr. J. S. FLETT, F.R.S., at present Assistant to the Director in Scotland, to be Director of the Geological Survey and Museum.

Dr. FLETT succeeds Sir AUBREY STRAHAN, K.B.E., F.R.S., who retires this month, when Mr. G. W. LAMPLUGH, F.R.S., Assistant to the Director in England, also retires.

Mr. Francis P. Webb, an American Mining Engineer, who is well known as a Shale Oil Expert in Colorado and Utah, has been some months in this country in connection with Shale. Before leaving for the States he presented to the Institution a book of most valuable and instructive photographs showing the great deposits of Oil Shale near Grand Valley and De Beque, Colorado; also the deposits near Watson, Utah.

Senor Mariano Arguelles of Bogota (Box 675), Colombia, late Chief, National Section of Mines, Ministry of Public Works, Spain, has been unanimously elected Honorary Member and Correspondent in Colombia of this Institution. He places his services at the disposal of Members interested in the Petroleum Industry in Colombia.

Mr. E. Lawson Lomax returned from India in June.

Royal School of Mines, Frecheville Research Fellowships.

The Imperial College of Science and Technology, South Kensington, London, S.W. 7, with which the Royal School of Mines is incorporated, is offering two Research Fellowships of £300 a year each, tenable for one year and possible renewal for a second year, to aid in carrying out any investigation or research connected with Mining, Mining Geology, Metallurgy, or the Technology of Oil, which in the opinion of the Selection Committee is of sufficient use or promise.

Applicants who may be Associates of the Royal School of Mines or others, and preferably men with some practical experience, should apply in writing to the Secretary of the College (from whom further particulars may be obtained) before 1st September, 1920, giving the nature of the proposed investigation, qualifications for the work and references.

It is anticipated that the Committee will make the awards by the end of November, so that the Fellowships and work may begin on 1st January, 1921. Holders will be expected to devote their whole time to the work which may be conducted at the Imperial College or in special circumstances elsewhere at the discretion of the Committee.

MILNE, *père*. By a regrettable confusion of names, the Annual Report for 1919, published in our last issue, No. 22, gave the name of Mr. Frederick Milne as a deceased member, in place of that of his father, Mr. Alexander Milne, whose loss had been noted with a brief obituary in No. 18.

SPECIAL COURSE OF LECTURES

in connection with the Oil Industries Exhibition, Crystal Palace.

The Institution has arranged for a course of popular lectures to be delivered in the Canada Building, at 6 p.m.

The following is the series:—

June 30th, 1920.

General Introductory Lecture, Sir Frederick W. Black, K.C.B., B.A. (London).

July 7th, 1920.

Wild Catting, E. H. Cunningham-Craig, Esq., B.A., F.R.S.E., F.G.S

July 14th, 1920.

Oil Storage, Transport and Distribution, H. Barringer, Esq., M.Inst.C.E., M.I.N.A., M.Inst.Mar.Eng.

September 1st, 1920.

Oil Prospecting, G. Howell, Esq., F.G.S., F.R.G.S.

September 8th, 1920.

Petroleum Refining, A. E. Dunstan, Esq., D.Sc., F.I.C., F.C.S.

September 15th, 1920.

Utilisation of Volatile Oils, W. R. Ormandy, Esq., D.Sc., F.C.S.

September 22nd, 1920.

Utilisation of Heavy Oils, Prof. J. S. S. Brame, F.I.C., F.C.S.

These Lectures will be published in a Supplementary Journal.

Forty-Fourth General Meeting.

This Meeting was held at the House of the Royal Society of Arts, John Street, Adelphi, W.C. 2, on Tuesday, 17th February, 1920, Sir Frederick W. Black, K.C.B. (President), occupying the Chair.

The Members of Council present were Messrs. Arthur W. Eastlake, J. Kewley, T. C. Palmer and Robert Redwood.

Letters of regret for unavoidable absence were received from Mr. H. Barringer, Sir John Cadman, Dr. A. E. Dunstan and Dr. F. Mollwo Perkin.

The President, at the opening of the meeting, announced that the second Annual Dinner would be held at the Connaught Rooms on the 23rd of March next; that distinguished guests were being invited to attend, and that very great efforts were being made in the direction of obtaining as good speeches as were delivered at the first dinner held last year. He trusted the members would do their best to make the dinner a great success. In calling on Dr. Ormandy to read his paper, he desired to inform the members that the author had prepared the paper under circumstances of great pressure, having had no more than four or five days for its compilation.

Dr. W. R. Ormandy, before reading his paper, explained that another paper should have been read before the Institution on the present occasion, but the author wrote to say he much regretted he was unable to prepare it in time. He (Dr. Ormandy) was asked if he could write something to fill the gap at three or four days' notice; and the contribution he was about to read was dictated to his private secretary on the afternoon prior to leaving for the Continent, whence he had just returned. The copy in the hands of the members had therefore not been corrected.

The following paper was then read:—

Recent Patents on Mixed Fuels.

By W. R. Ormandy, D.Sc.

In the modern civilised world questions of transport are of the greatest importance; indeed transport is in a sense the basis of civilisation. This was brought home to us in a very definite way during the recent railway strike, and only the existence of large numbers of internal-combustion engined vehicles, and considerable stores of liquid fuel suitable for use therein prevented an alarming situation.

We are coming more and more to recognise that industrial

development, not only in any one country but between countries, is dependent upon quicker and more flexible means of communication.

Vital though the railway is and must remain, there is an enormous field which the railway cannot touch, and in this field the internal-combustion engine reigns supreme fed with liquid fuel.

A merely cursory glance at the statistics dealing with the world's fuel production suffice to show that coal will for long remain the controlling and predominant factor. The total production of crude oil in the whole world is little more than a quarter by weight of the British coal production. I do not intend at this time to deal in any way comprehensively with the broad and important question of liquid-fuel supplies. It is sufficient to know that the motor-car industry is growing at a rate which few could have foreseen 20 years ago. In America alone, in 1919 the production of road-motor vehicles provided with liquid-fuel engines, was approximately 1,900,000. It has been estimated from enquiries made by the American Government that one half of all motor vehicles used in America are employed for commercial purposes, largely by farmers in the wide spaces of that country. If we add to the above almost incredible total, the numbers of motors made in the rest of the world, the petrol- and oil-driven electric lighting and pumping sets, marine engines and aeroplanes, we shall be safe in concluding that not less than the equivalent of 2½ million motor vehicles were produced in 1919. It is, I think, agreed that 400 gallons per annum is a moderate estimate for the consumption of vehicles averaged as above described. This points to an increasing demand for volatile liquid fuel, growing at the rate for 1919 of 1,000,000,000 gallons per annum. I will not enter into the vexed question as to the ability of the oil producers to meet this growing demand, but will merely point out that the estimated crude-oil production of the world has grown from 50,000,000 tons in 1912 to 75,000,000 tons in 1919. A thousand million gallons of petrol represents over three million tons, and assuming the high yield of 20% of petrol from average crude, this quantity requires 15,000,000 tons of crude oil for its production. The increased production in crude in 7 years is estimated at 25,000,000 tons. The output of motors for 1919 will require 15,000,000 tons of crude to provide the volatile liquid fuel to keep them on the road.

Whether the supply is keeping pace with the demand or not, the price of petrol is steadily rising, and at last the attention of motor makers and motor users is being seriously directed to the fuel question. That the motor maker as well as the motor user have exhibited an incredible apathy towards the fuel question is

undeniable. It is not until the motor industry stands in danger of fuel starvation, or until prices rise so high that the demand for vehicles inevitably slackens, that a serious effort is made to tackle the situation. Naturally this effort comes too late to be of the maximum benefit to those concerned, for it is impossible to produce in a short space of time, the vast quantities of new fuels which are required.

There is a parallel in the case of india-rubber. The motor industry would have been in a parlous state had it been dependent upon the supplies of wild rubber, but fortunately far-sighted people took up the plantation and growth of rubber trees, until to-day the supply is fully adequate to meet the ever-growing demand, though this was not carried out without the industry passing through days of great difficulty and of high prices, at the period when the plantation production was not able to balance the difference between the production from native rubber and the growth of the world's demand.

A similar situation seems likely to arise with regard to cotton. The tyre industry requires a long-staple cotton than which nothing has proved so good as our own Egyptian supply. There seems every probability of difficult times ahead owing to the inability of the Egyptian supply to meet the growing demand for tyre fabrics, as well as for the other purposes for which this favourite long-staple product is in great demand. The British spinners have been almost as apathetic in relation to this question of their vital raw material as has the motor world, and only now are they seriously awakening to the discovery that large sums will have to be raised by the industry in order to develop and increase the Empire's production of suitable raw materials.

The questions relating to rubber and cotton may seem digressions but they are introduced in order to inculcate a needed lesson.

In view then of an industry faced with increasing prices for its vital raw materials, whatever may be the situation as regards available supplies, I thought it would be of interest to go through the patent files back to 1913, in order to find out what evidence there was of an awakened interest in volatile fuel matters. Few people probably realise the interesting nature of the patent office records. These records serve in a sense as an industrial barometer. For a year or two they are thick with applications dealing with various aspects of one particular subject, and then little more is heard on that particular matter. The only general deduction that one can draw with certainty from the patent applications of the last five years is the universal assumption that alcohol in

some form or other will be a constituent of the motor fuel of the future.

That ethyl alcohol could be used alone as a motor fuel has, of course, been recognised from the earliest days of motor production, but it was equally recognised that owing to the low thermal value of this fuel, and to its comparatively low vapour-pressure it was by no means an ideal fuel for the purpose, and certainly so long as the convenient volatile hydro-carbons of the paraffin series, known under the generic term of petrol, were available at a reasonable price, there was no necessity to encourage the use of either alcohol alone or in admixture with other bodies.

In 1913 patents were taken out for the utilisation of mixtures of crude alcohols produced by the fermentation of peat with kerosene or the like bodies. It is particularly emphasised in this patent No. 28072 of 1913, that these alcohols or carbinols consist of the lower alcohols, with fusel oil and similar bodies. This is important in view of claims which are made at a later date, and which will be referred to further on. Further in this same patent it is stated that the inventor, or should we say author, was aware that in 1870 it was proposed to mix hydro-carbon oil such as petrol with fusel oil and any of the oxides or hydrated oxides of the hydro-carbons for the preparation of an oil for illuminating purposes.

This patent is of interest, because it emphasises the public character of the knowledge that ordinary commercial alcohol containing 5/10 % of water can be caused to mix with paraffins and similar hydro-carbons in the presence of fusel oil or higher alcohols. I need hardly point out to this audience that it is a well-known fact that the miscibility of alcohol and paraffin hydro-carbons is dominated by the presence or absence of a comparatively small amount of water in the alcohol, nevertheless patent No. 109802 is granted for a claim to a mixture of anhydrous or substantially anhydrous alcohol with petrol as a fuel for motor engines. It is, I think, quite impossible to obtain a patent of this sort in Germany, because in that country the Patent Office is allowed to cite knowledge contained in well-known text-books and technical literature, as well as information embodied in previous specifications, in contesting the issue of a patent. It does not seem to me that there is much invention or discovery in the substance of these patents. The fact is perfectly well known that anhydrous alcohol and petrol will mix, and it is equally obvious that a mixture of this fuel will burn in an internal-combustion engine. This question of miscibility of alcohol and paraffin hydro-carbons again arises in patent No. 109806. The patentee points out that a desirable

fuel would be a mixture of paraffin oil, petrol and alcohol, meaning thereby commercial alcohol of approximately 95 volume per cent. strength. He points out that such alcohol will not mix with paraffin and petrol or admixtures of these, but that it can be caused to do so by making use of what he calls a mixing or combining agent, which he points out must be something which is soluble in both constituents of the proposed mixtures. As an illustration he instances that anhydrous fusel oil or anhydrous amyl alcohol will cause such admixture to take place, citing as an example :

2 volumes of paraffin oil.
One volume petrol.
One volume 95 % alcohol and
0·4 volume of fusel oil or amyl alcohol.

This patent was granted subject to a reference to certain prior patents in pursuance of section 7, sub-section 4, of the Patents and Designs Act of 1907. Among these cited patents are the 28072 of 1913 and 2515 of 1914. One of these has already been dealt with, being the patent for the admixture of mixed alcohols from peat fermentation containing fusel oil, with paraffin.

The No. 2515 of 1914, which is also cited comes within another category. It is the type of patent which adds to the gaiety of an otherwise sombre publication. The fuel which this patentee proposes to employ consists of :—

3½ litres of petroleum boiling from 150/270°.
½ litre „ boiling from 65/110°C.
½ „ „ boiling between 110/150°C.
plus 200 cc. of 96 % alcohol.
plus 2 cc. of ethyl ether.
plus 1 cc. petroleum ether to which may be added
½ litre of benzol and ½ litre of naphthalene.

The subject matter of patent No. 134766 is closely related to that of 109806. Here again it is recognised that commercial alcohol and petroleum distillates do not mix, and although the earlier patent claims the use of any mixing or combining agent which is miscible in each of the above-named constituents, nevertheless the later patent claims the use of a compound containing the acid-radicle of an hydroxy fatty acid adapted to blend the other constituents, in other words, the later patent instead of using amyl alcohol or fusel oil, uses another class of chemical compound to perform the same service.

The subject matter of 136452 taken out by the same patentee as the last patent herein referred to, again is closely related to the earlier patent of 109806 for a fuel made up of gasolene, kerosene

and ethyl alcohol, in which the alcohol is caused to mix with the other constituents by adding the acids obtained from linseed oils as a mixing or combining agent.

Such then appears to be the history of comparatively recent work on the admixture of alcohol with the paraffins and the means employed to bring about such admixtures as established by the Patent Office records.

Alcohol and Ethyl Ether.

The fact that alcohol, particularly in cold weather, has a low vapour-pressure, has led to attempts to mix with the alcohol, bodies which would increase the vapour-tension. We have dealt above with the proposal to admix alcohol with the volatile paraffins: we will now turn to the efforts which have been made in the direction of the employment of ethyl ether.

We have already noticed in patent No. 2515 of 1914 that it was proposed to add 2 cc. of ether to something like 5 litres of a complex mixture. That this can be of any practical importance would seem unlikely, but in patent No. 21316 of 1914, considerable quantities of ether are employed, the claim being for a fuel for internal-combustion engines, consisting of a mixture of alcohol and ethyl ether in the proportions of 86 parts by volume alcohol to 10 parts by volume of ether together, if necessary, with denaturing agents. That alcohol and ether will mix perfectly in all proportions is, of course, well known.

In patent No. 24262 of 1914, the claim is made "that alcohol cannot be said to be improved as a fuel for use in ordinary type of carburetters for motor-cars or aircraft by the addition of ether, until the latter amounts to 40 % by weight of the mixture." It further states that the improvement continues up to the addition of 60 % by weight of ether, claiming the best all-round results for a mixture of equal parts by weight. This forms the first claim of the patent. A further claim is for the addition of a ½ % of ammonia which is stated to overcome the tendency that alcohol-ether fuel is said to have, namely, to cause corrosion in the engine, especially to the valves and cylinder. The fuel made under this patent specification, which has been used to a considerable extent in South Africa is known as "Natalite." In a later specification the same inventor claims the use of trimethylamine in the place of ammonia for the prevention of corrosion.

We have seen that in the last two specifications referred to, the main claim was for admixture of alcohol and ether with the ether varying from 40 to 60 %. In patent specification No. 123450, a

claim is made for alcohol ether in much the same proportion, but with the addition of 5 to 30 % of kerosene together with denaturants if required. In this case the ether is added partly as the mixing or combining agent referred to above in patent No. 109806 to cause the petroleum and the alcohol to combine, but also to give the necessary vapour-tension to the mixture.

The later patent application 133434 consists of an admixture of ether and alcohol with 5 to 50 % of any suitable distilled hydro-carbon oil. The patentee describes a method for making an ether-alcohol mixture by passing alcohol vapour through sulphuric acid and alcohol in the ordinary manner, and mixing the condensate, which consists of alcohol and ether, with further alcohol, instead of stating a definite proportion of ether to alcohol.

Admixture with Gases.

The patentee of No. 103720 claims that by passing kerosene under high pressure through narrow interstices in the presence of a gas containing hydrogen or a hydro-carbon gas between a specified range of temperatures, the gas is caused to combine with the paraffins, producing a fuel having a higher vapour-tension than the original paraffin.

The method employed in patent 104330 for causing the inter-action between a heavy hydro-carbon of the paraffin series and hydrogen or a light hydro-carbon gas of the paraffin series, is by the employment of the silent electric discharge. The inventor claims that by using voltages of the order of 5,000 he is able to cause the combination of a lubricating-oil vapour with marsh-gas, with the formation of octane, and he refers in the specification to the fact that higher frequencies in the electric discharge are required to obtain low-boiling point production than where less complete cracking is required. Here there is no doubt that the inventor specifically claims to have caused chemical combination of the hydro-carbon gas with the heavy oil-vapour to produce new bodies of a lower boiling-point.

Patent No. 105256 is but one of a considerable number of a similar type where an effort is made to use acetylene as a means for lowering the ignition-temperature of bodies otherwise of low volatility. This patent relates to the treating of kerosene or fractions boiling above petrol but below kerosene. It is obvious that acetylene merely mechanically dissolved in kerosene or petrol-kerosene mixtures will easily come out. He claims the addition of a small amount of say ½ to 1% of ether or acetone or alcohol, as acetylene

is more soluble in these bodies. It has been proposed that acetylene should be dissolved in acetone or in any liquid in which it is very soluble, and that the solution should then be added to the paraffins or other hydro-carbons the ignition-temperature of which it is desired to lower. It is difficult to see, therefore, where is the novelty contained in the above specification.

Patent 107217 is nothing more or less than the means of carrying into effect some of the suggestions made in the last-mentioned specification.

The patentee of 111933 claims that by saturating bodies as dissimilar in their properties as mineral oils, coal-tar oils and shale oils, with hydrogen or hydro-carbon gas in the cold or even at a reduced temperature, and then carrying on distillation, the yield of volatile liquids is increased. In other words, we are told that saturated paraffins or ring-compounds take up hydrogen in the cold to form bodies sufficiently stable to stand distillation.

Patent No. 112741 is a claim for the use of alcohol saturated with acetylene as a suitable fuel for motor-car engines. Alcohol is distilled, and the vapour mixed with acetylene gas and the mixed vapours condensed. It is claimed that this gives good saturation with the gas.

The extraordinary tendency which the last but one specification indicates of hydrogen or hydro-carbon gases tending to combine with saturated and inert chemical bodies in the cold is made use of more fully in patent 119066. Bodies such as petroleum, resin oils, &c., are subjected to a pressure in the cold in the presence of such bodies as hydrogen, coal-gas, pintsch gas, and indeed, at one stage at a temperature of 15° below zero, acetylene is introduced at a pressure of 12 atmospheres, and thereafter the pressure is removed. Either the gases are present as a super-saturated solution, or they have entered into combination, that is, if they remain in the liquid.

The patentee of 120792 claims saturating alcohol with acetylene by bubbling the gas through the liquid, and claims the addition of 1% of acrolein as a denaturant. This latter addition would appear to be the novelty in this invention.

In connection with the above-described patents it is interesting to note that the use of such gases as acetylene merely mechanically dissolved in stable liquid fuels was seriously considered by the Inter-Departmental Committee on the Production and Utilisation of Alcohol for Power purposes, but it was considered that the danger attached to the use of such solution was too great, as a mechanically-dissolved gas is given off very readily, and would

make the storage and handling of such liquids exceedingly dangerous.

It is impossible in the short space of one paper to deal with the many other aspects of the volatile liquid-fuel problem which are touched upon in the *Patent Journal*, but occasionally one comes across some light relief such as specifications which claim the use of a fuel consisting of a mixture of 10 gallons of equal parts of petrol and paraffin oil mixed together with 1oz. of pine fluid, mirbane, isinglass and tartaric acid. It is claimed that the object of these inventions is to provide fuel which will be cheap to manufacture, cleanly in use, obviate carbonisation, have little or no destructive effect on the valves and other parts, and be of such a character that it can be modified in strength to suit engines employed with light or heavy loads.

General.

We have seen that patents have been granted for admixture of bodies which every chemist knows will mix, and which every engineer knows will drive an internal-combustion engine. Between the years 1900 and 1910, I tried all sorts of mixtures of fuels including petrols, paraffins, benzol, light solvent naphtha, methylated spirits and ether, and although I recognised a time would come when alcohol in some form of admixture would have to be a motor-fuel, I never contemplated the possibility of taking out a patent for admixtures which it was perfectly obvious to anyone with an elementary chemical knowledge could be employed if the ingredients thereof were obtainable in sufficient quantity at a reasonable price.

Many of the patents which have been referred to are certainly not inventions or discoveries. They are granted, I suppose, as patents in this country, because the patent records of the previous 50 years cannot show that anything of the sort has previously been patented. I assume that if one applied for a patent for the utilisation of the chemical substance H_2O, either alone, or in conjunction with small quantities of alcohol as a beverage that it would be rejected on the grounds that it was public knowledge at the time the application was made. It is equally public knowledge to anyone skilled in the art in question that such liquids as paraffin, petrol, benzol, alcohol, ether, acetone, will either mix in any proportion, or in restricted proportions, and that by admixture for example of petrol with benzol a certain amount of alcohol can be caused to dissolve in the mixture which would not dissolve in the petrol alone. It is equally common knowledge to chemists

and engineers that any admixture of two or more volatile fuel bodies will result in a third substance also capable of being used as a fuel.

Until quite recently section 11 (1) (b) of the Act, before it was amended, stated that the grounds of opposition were :—

> "the invention has been claimed in any complete specification for a British Patent which is or will be of prior date to the patent the grant of which is opposed."

Thereafter follow words limiting this to patents not more than 50 years old.

As amended it is now possible to bring up in opposition information which has been made available to the public by publication in any document (other than a British specification published in the United Kingdom prior to the application). This enables anyone to oppose the grant on the ground of a publication contained in a foreign specification which reached this country before the date of the application, of any publication in a technical paper, or in anything which can be called a document.

It would appear that evidence of prior use or prior knowledge which has not been reduced to the form of a public document before the date of the application in question could not be utilised under this section.

It may be of some interest to know what liquid fuels have been employed on the Continent during the years of the war. Very recent work of Dr. Formanek states that many mixtures were employed having as constituents petrol, benzol, toluol, alcohol and paraffin together with smaller additions of ether, acetone and carbon bisulphide, all of which were more or less satisfactory, but that those mixtures to which picric acid, ammonium nitrate, nitrobenzene, aethyl nitrate and other nitro compounds were added were not successful. He considers that attempts to use naphthalene in any quantity were also a failure.

He points out that an admixture of petrol and benzol containing only 20/30 % of petrol became turbid at about 0° C. and the benzol crystallised out at minus 10. However, a mixture of 40% petrol and 60% of a commercial benzol containing about 30% of toluol did not freeze until below minus 25° C.

The fact that petrol and alcohol if the latter be water free would mix in any proportion is referred to, but it is pointed out that when working with commercial 95% alcohol it is necessary to use some material such as benzol to keep the alcohol and the petrol in solution, and a mixture of 20/25 parts of petrol, 50/25 of benzol, and 25/50 of alcohol is recommended, the benzol being increased for use in winter.

The same writer points out that benzol and alcohol have been used by motor-bus companies for years, and he recommends for summer 40 of benzol to 60 of alcohol, and points out that 25 of benzol to 75 of alcohol is a difficult mixture to work with even in summer unless some form of pre-heater be employed.

Elsewhere reference is made to mixtures of light and heavy solvent naphtha which, with petroleum added, was used for heavy motor vehicles.

Among the mixtures used in Prague may be mentioned Etol, 25% petroleum, 50% alcohol and 25% ether and Motorit, 25% petroleum, 50% alcohol and 25% benzol.

Reference is made also to all sorts of mixtures of ether, acetone, alcohol, benzol, petrol and petroleum.

It is not my intention to express any pronounced opinion upon any of the specifications, but it is surely time that the Patent Office ceased to grant patents for admixtures of every conceivable burnable organic liquid which might possibly be used as a motor-fuel.

We shall be having no doubt in the near future patent applications for admixtures of benzol and petrol though they have been used and sold for years, and with like certainty we shall have alcohol in admixture with benzol and petrol with and without ether, and the possible utilisation of acetone will also be claimed. The fact, of course, is that any admixture of liquid hydro-carbon which can be vaporised by the modern carburettor, or volatilised by means of some form of pre-heater, such as is used in a paraffin carburetter, can be employed as a motor-fuel, and improvements in carburetter will continue to be made which will allow of the less volatile products being used in increasingly large quantities. It is a distinct danger both to the motor user, to the motor manufacturer and to the general community that such patents should be allowed to exist.

DISCUSSION.

The President, in proposing a very hearty vote of thanks to Dr. Ormandy for his excellent paper, said the author had managed to extract a good deal of instruction and some little humour from patent specifications, which to most of them were of a rather forbidding nature. Chemists in particular would find much of interest in the paper. One question in which he was greatly interested was that of the provision of the raw material from

which alcohol could be made, a subject which was carefully considered by the Committee on Power Alcohol, on which both the author and himself sat. As the author had stated, unless the raw material could be obtained in very large quantities the amount of power alcohol obtained did not seem to be susceptible of very great development. There was a great possibility, especially in America, of a good deal of distilling or refining capacity being set free. If America went absolutely dry and enforced the complete prohibition of the manufacture and consumption of alcoholic liquors, a great amount of capacity would be available for use for some purposes of industry. He remembered when he was in America that many of the big breweries were already turning on their stills to the production of non-alcoholic drinks, but even when that was done to the utmost extent in America there must be a large capacity left for the production of alcohol for industrial purposes. One point which the author had raised incidentally, and not as the chief subject for discussion, was the practice of the Patent Office in the granting of patents. One had a little fellow feeling for the staff in the Patent Office who have to search back over the patents for fifty years, and if they have to search through all sorts of publications as well their difficulties would be enormously added to. In dealing with mixtures such as those described in some of the documents referred to by the author there was a good deal of room, he would not say for evasion, but for competition, i.e., if it was possible to get a good patent for certain ingredients of a compound in certain definite proportions it would appear equally possible to utilize or obtain a patent for other ingredients and proportions by which the same or similar results could be obtained. Therefore, in this instance, he did not know that the present practice of the Patent Office could be regarded as in any way a bar to progress. He did not say that that was a very complete excuse for the present procedure under the Patent Laws, but, so far as he could judge, there was no very serious grievance in regard to such matters as the author had put forward. An applicant could very easily make some other mixture, altering the ingredients and proportions, and perhaps get equally good results ; and if he wanted a patent for it apparently he would experience no difficulty in getting it.

Mr. Mitchell said that with regard to the practice of the Patent Office in the issue of patents, it did not follow that a patent was granted as easily as was sometimes imagined. Some little time ago he wished to patent a process for the separation of ammonium chloride into ammonia and hydrochloric acid gas by taking advantage of a process of diffusion, and the patent was refused

on the ground that diffusibility was known to Graham. In some cases the Office granted a patent very easily, but in other cases they put such difficulties as the one he had mentioned in the way of the applicant. He had been very much interested in the author's statement that £3,000,000 had been asked for one of the patents referred to. He did not know whether it was a special adaptability he had for meeting curious people, but he happened in his time to have met two or three people of that nature. He remembered on one occasion a gentleman informed him that he had the option on the production of a new kind of fuel which would be cheaper than ordinary petrol, it having been proved that it would drive a motor at least twice as far as ordinary petrol on the same consumption. The inventor, a Frenchman, wanted £1,000,000 for the formula. After very great difficulty in getting the inventor to give any information at all, he eventually obtained a sample of the stuff, which on distillation turned out to be ordinary petrol containing about 5 per cent. of amyl acetate to make it smell nicely. The negotiations took place in the office of a very large firm in London. On another occasion he was sent for by an American gentleman who had a great idea with regard to a new petrol. On the first visit he talked for a long time without giving any information, apparently because he wished to sum him up before he dared let go his brilliant idea. On the second it transpired that he wished him to experiment with a mixture of about 10 per cent. to 20 per cent. of nitro-glycerine in petrol, as he thought it would prove interesting!

Mr. W. J. A. Butterfield, after expressing his indebtedness to the author for his most interesting paper, said he wished more stress had been laid on the advantages of benzol as a blending agent. Benzol was of more service than anything else in preparing blended or mixed fuels, because it would mix with almost anything except water in any proportion. One reason why so many curious preparations had been patented was, he thought, that the inventors aimed at providing a fuel which would escape the petrol tax, and in order to do that they mixed small quantities of strongly smelling or otherwise highly potent materials with blended fuels, in order to disguise the fact that a large proportion of the mixture would otherwise have been easily recognised as taxable. He was sure that was the case, because in many of the preparations which had been brought before him one of the first questions that had been put to him was: "Will this preparation be taxed or not?" It was a great advantage to a mixed fuel if it escaped the tax of 6d. a gallon. That, however, would probably be a thing of the past,

and he thought in the future there would be fewer of such fancy patents. With regard to the production of power alcohol in this country, there was really only one source of cellulose, sugar or other material which, by conversion if necessary, could be made fermentable, which would not deprive the country of some of its essential food supply for people or stock, namely, fibrous peat. A great many experiments had been, and were still being, made with peat. A group of German chemists were interested in pushing one process up to the outbreak of the war. They succeeded up to a point, and hoodwinked various people who investigated the process into believing that they had done much more. Sooner or later, however, fibrous peat would be used as a source of alcohol for fuel purposes. He thanked the author for his excellent résumé, and only wished he had had time to go back further than 1913, because some of the most interesting patents were of a rather earlier date.

Mr. Howe said that he desired to ask a question in connection with what had been said in regard to the scarcity of raw materials for the production of alcohol. He remembered hearing a very interesting lecture on the subject of the production of beet in this country, and it would be of interest if the author could state whether anything had been done in that direction in regard to the intercropping of beet with wheat, which was one of the points of importance mentioned. It was suggested on the occasion to which he referred that that scheme might have the effect of bringing about a big production of the necessary output of alcohol.

Mr. Gordon Pitt, in reply to Mr. Howe's remarks, said it was a matter of common knowledge that the Kelham beet-growing proposal was likely to go forward, and it seemed likely that after the sugar for which the beet was primarily produced had been extracted there would remain in the beet pulp a certain amount of sugar which would be recoverable as alcohol. He thought he could not be far wrong in stating that the beet pulp itself would provide quite a useful source for the production of alcohol. It was not for him to suggest at the moment exactly how that would be carried out, but he thought that beet pulp would undoubtedly be a suitable raw material for the production of alcohol; and it ought to be in the interests of the motor industry generally, although not perhaps of the members as petroleum technologists, to see that if any large quantity of that raw material became available it was ear-marked for some such purpose rather than returned to the land as manure, which, he thought, was the proposal of the people who were interested in the cultivation of beet from the point of view of sugar only. He happened to have had an experience which he

thought could not be common to very many people who were "oily," of being closely associated for a short period with sugar production in the West Indies, and he had once or twice raised the question with the author, when he had had the opportunity of discussing it with him, of the possibility of using the so-called megasse or bagasse, which was the crushed cane fibre after the sugar had been extracted from it, as a source of alcohol. It certainly contained, from a chemical point of view, a good deal of material which could be converted into alcohol. Under present conditions, many hundreds of thousands of tons of it were annually burned as fuel. It was an extremely bad and inefficient fuel, because it was always wet and very inconvenient to dry. Probably the author, with his extraordinary facility for rapid calculation, could, before the end of the meeting, if he cared to do so, say how much 100,000 tons of that material would represent in alcohol, but it must be a very large quantity. Referring for a moment to the general scope of the paper, it seemed to him, knowing as he did something of the author's methods, that his intention had probably been, rather than to introduce the members to any extremely interesting or valuable patents, to point out that public interest, as indicated by the Patent Office records, had centred around the question of mixed fuels in the last six or seven years; but surely the actual result of that interest, as evidenced by the patents taken out, had been almost futile. Dealing with the matter from the point of view of his own deep ignorance, he thought that none of the patents, or at any rate very few of them, were in any sense revolutionary or likely to influence the acute motor-fuel problem to any considerable degree. Although the first interest of the members was naturally that of petroleum, its membership also comprised a combination of chemical, engineering and general technical knowledge whose main interest was the internal combustion engine; and it seemed to him that, in such a community, if the question of mixed fuels were introduced and became of interest, the members of the Institution ought to be able to carry the subject a great deal further than there was any evidence that recent patents had carried it. Owing to the enormous growth in the demand for liquid fuel for internal combustion engines, and the more or less consequent rise in its price, there was a crying necessity for some sort of either substitute or diluent for petrol. Something would have to be done; it was impossible to go on as things were at present. The increased demand and the increased price were either going to limit the activities of the motor industry and the enormous value to the community in general of motor transport, or something had got

to be done to eke out the available supplies of liquid fuel. It was well known to the members that the author had for years past given a great deal of his time and given enormously valuable service to the community in general by keeping the question of power alcohol more or less prominently before the public, or at any rate before the technical world; and, personally, he had hoped before coming to the meeting that the author would have stated in his paper something which had already been done which was a solution to the problem. There was little that was practical in any of the patents referred to. Many of them were simply childish; the "lady's cookery recipe" was altogether too absurd, and no new general principle seemed to have been established; they were more or less where they were previously. It was known that petrol, alcohol and benzol could be mixed and used as motor fuels provided that certain comparative conditions were observed, and the members therefore had to concentrate their attention on the provision of the necessary quantities of raw materials. There was no one present who would take more interest, even though it might be a painful one, than he would in anything which would have the result of substituting another liquid fuel for petrol. Most of those present at the meeting were so closely associated with petrol in some shape or form that, to put it at its lowest factor, their living would be gone if petrol were completely substituted, but there was little or no reason to suppose that that would come about. What they were really interested in was the augmentation of its supplies, and as no definite new principle had been established he thought concerted efforts should be made in the securing of them.

Mr. Esling enquired whether the author had come across a mixture of fuels containing turpentine, suitable for internal combustion engines of the ordinary motor type. A short time ago a mixture of that sort was put on the market for assisting ordinary motor fuel in the matter of easier combustion at a low temperature. The mixture, which was of American origin, contained approximately the following ingredients:—Motor Spirit, 34 per cent.; Ether, 38 per cent.; Oil of Turpentine, 28 per cent. For use it was recommended to add five parts of the "Dope" to 50 parts of Motor Spirit, and 45 parts Kerosene. The "Dope" was protected by American Letters Patent, and the usual fabulous price was demanded for the right to manufacture and market it.

He also wished to ask if the author laid claim to being one of the first men to introduce the question of industrial alcohol for the internal combustion motor. Personally, he had heard Prof. H. E. Armstrong advocate in 1905, the extensive production of alcohol

from vegetation, since alcohol as a motor fuel must eventually be used, as the supplies of petroleum spirit were likely to be insufficient for the future use of motors in particular.

When he received the notice of the meeting, stating that the author would deal with the question of mixed fuels, he hoped that something would be said about "Colloidal" fuels, and also, perhaps, some of the recent patents that were the result of the Government's enquiry during the war for a process for mixing coal tar oil with petroleum oils, but the author seemed to have confined himself more particularly to the motor question.

Dr. W. R. Ormandy, in reply, said the President had referred to the large amount of plant that might become available in America owing to the fact that that enterprising and cold-hearted nation had decided to give up alcohol for potable purposes, and he had also stated that he thought a certain number of the stills might be used for making non-alcoholic drinks; but at any rate the fact remained that they had an enormous amount of distilling plant which they would undoubtedly endeavour to use for the production of industrial alcohol, and they were very keenly and urgently looking for new uses for alcohol for industrial purposes. He doubted very much, however, whether they were thinking at the present moment of its utilisation as a motor fuel, because America was not yet faced with prices for petrol similar to those with which the people in this country were faced with, owing to the fact that America was a very large petrol-producing nation.

The President, interposing, said that the price of petrol in America was actually higher in percentage than it was in this country—he meant the increase had been greater.

Dr. Ormandy, continuing, said the cost of production of alcohol depended on the raw material costs very largely. The actual cost of making it from a given raw material was comparatively small, and the price of petrol was too low, having regard to the cost of the alcohol raw material, to justify them in looking upon that as a means for utilising their plant at present. They obtained a better price for alcohol for its conversion, by catalytic or other processes, into a range of chemical products and such-like things. He had purposely omitted to deal with the question of the manufacture of alcohol and its relation to raw materials, because the object of the paper was quite other. The manufacture of alcohol and its relation to raw materials was in itself a very important subject. Mr. Mitchell had referred to the Patent Office quoting the fact that Graham had discovered the law of the rate of diffusion, and that they therefore would not grant a patent for the separation of

ammonia and hydrochloric acid from ammonium chloride in the form of vapour. If Mr. Mitchell claimed the fact itself, or endeavoured to claim an established principle, and did not claim specifically the means whereby that principle was carried into effect, that in itself was sufficient to justify the Office in refusing the grant.

Mr. Mitchell said the claim was made for a special apparatus.

Dr. Ormandy, continuing, said in that case, if he had been in Mr. Mitchell's place, he would have persisted and made things very unpleasant for the Office. Mr. Butterfield had referred to the fact that he had not sufficiently emphasised the admirable nature of benzol as a mixing agent owing to its wide degree of solubility in many bodies. He did not think that after the magnificent manner in which the A.A. and M.U. had advertised benzol, pointing out how benzol was the best motor fuel, until the benzol producers had realised it to such an extent that they wanted to put the price up higher than that of petrol, that it was necessary for him to emphasise what had been said in that respect. The removal of the tax would undoubtedly tend to diminish the flow of inventive ideas or cool the heated imaginations which had tended to produce a lot of peculiar patents such as those to which reference had been made. With regard to the question of obtaining alcohol from the fibrous material of peat, which was simply tantamount to saying the production of alcohol from cellulose, peat being a large and comparatively cheap supply of cellulose material. In that connection they came back again to the consideration of what was known as the Classen process for converting cellulose, by means of acid treatment and hydrolysis, into a sugar which could be fermented. He believed that operation had been carried out on a very large scale by one of the largest chemical firms in America from a form of cellulose much purer and much easier to deal with than peat, namely wood sawdust, and that they had succeeded in producing hundreds of thousands of gallons of alcohol by that process, but with labour and fuel costs which did not justify them in continuing the manufacture of alcohol as a fuel in competition with existing fuels. The fact was that it was very difficult to convert cellulose when it was mixed with lignine bodies, as it was in wood, into fermentable sugars, because if a certain amount of acid were added, just sufficient to do the conversion in a reasonable length of time, it converted some of the cellulose into sugar right at the start, and before it got at the more resistent cells it had already begun to destroy, under the conditions of temperature and pressure obtaining, the sugar which had been most easily and readily produced. As a result the yields in practice fell below one-half of what was theoretically possible. He had been told, however,

that the enterprising and almost ubiquitous firm of Fords had devoted their attention to the subject because they, as the largest producers of motor-cars in the world, realised that their whole industry was jeopardised by the growth in the price and the lack of supply of motor fuel, and they claimed that they had been able to produce from straw cellulose or straw residues alcohol in yields which were very much higher than the best that had been previously obtained by any modification of the Classen process. Although the foundation of the method was mentioned to him he was not in a position to pass the information on, but it had been stated in the papers that Ford himself claimed to have produced alcohol from straw at a price which even in America would enable it to compete with petrol. In that case, the sooner the information was handed out for the benefit of humanity in general the better it would be. Mr. Butterfield had suggested that he should have examined the patents further back than 1913, but unfortunately the time at his disposal only allowed of a certain amount of work, and it took quite a long time to go through the records. His main object had been to find out what had happened in the period since the commencement of the war and during the time that the price of petrol had been growing and the world at large had recognised that there was likely to be a shortage. In reply to Mr. Howe, who had asked a question in regard to beet, beet would primarily be used in any case for producing sugar, and beet molasses, the residue, would be used for making alcohol; but the quantities which would be produced in that way were not large enough at any rate to have any serious effect on the market, which was growing at such a tremendous rate. With regard to the manufacture of alcohol from sugar residues abroad, a subject referred to by Mr. Gordon Pitt, he had recently seen new processes for the purification of sugar which were particularly applicable to tropical climates and to sugar produced from the sugar cane which he thought would result in minimising the amount of fermentable sugar in the molasses and in reducing the amount of molasses to such an extent that the available sources of molasses would be reduced, for the reason that sugar was at present, and would remain for a considerable time, a much more valuable product, and consequently manufacturers and growers would produce all the sugar they could rather than produce alcohol from the residue. Any improvement which increased the yield of crystallisable sugar and diminished the yield of non-crystallisable sugar found in the molasses would be adopted by sugar makers. With regard to bagasse, in many cases sugar factories were situated in districts where other fuels than bagasse were difficult to obtain,

or were not obtainable at all. It was astonishing how rapidly, in a sugar factory using large quantities of fuel, the price of the timber in the surrounding districts increased, owing to the increasing distance which it had to be hauled. In any case, considering the very difficult nature of the cellulose in bagasse, and the way in which it was mixed up with siliceous material on the outside, he thought it was a most unpromising material to start upon. Further, he believed it had been proved beyond all requirements of further demonstration that if plenty of fuel was otherwise available the most satisfactory way of using bagasse was to employ modern machinery, to get rid of the siliceous outside by special crushing, and use the fibrous material for the manufacture of brown and packing papers. In reply to Mr. Esling's question, he imagined that turpentine could be used in a case of emergency, but having regard to the fact that turpentine was an oxidisable oil, he thought it would tend to cause trouble. It was not an ideal substance for the purpose, and, generally speaking, the market for it as a material for paint-making, as dryers and as a thinner, was such as to render the price prohibitive. He did not claim in the least to have been the first person to urge the importance of the study of alcohol for fuel purposes, but even if Prof. Armstrong did refer to it in 1906 he (the author) went to Germany in 1905 on a special mission to study alcohol engines, which had then been running in Germany for 13 years. He did not touch upon the question of colloidal fuels and the mixture of crude and tar oils, because the object he had in view was primarily to deal with the most pressing subject at the moment, that of volatile fuels. The question of the heavy liquid fuel for burning under boilers, which was a criminal and wasteful way of using a valuable material, and the application of such oils for Diesel and other engines, was sufficient subject-matter for another paper. Perhaps the time would come, before very long, when that mysterious stabiliser, which enabled 30 per cent. of coal dust to be hung up in the fuel oils of America, would become known to them in England, so that it would be possible to discuss it from a scientific standpoint; but at the present moment they were dealing with that mysterious quantity which scientists generally referred to as x.

The meeting then terminated.

Forty-Fifth General Meeting.

This meeting was held at the House of the Royal Society of Arts, John Street, Adelphi, W.C. 2, on Tuesday, 16th March, 1920, Sir Frederick W. Black, K.C.B. (President), occupying the Chair.

The Members of Council present were Mr. H. Barringer, Prof. J. S. S. Brame, Sir John Cadman, K.C.M.G., Mr. E. H. Cunningham Craig, Mr. Arthur W. Eastlake and Dr. W. R. Ormandy.

Letters of regret for unavoidable absence were received from Mr. T. C. Palmer and Dr. F. Mollwo Perkin.

The Hon. Secretary (Mr. Arthur W. Eastlake) announced that the following gentlemen had been elected :—

As Members :—Denovan Howard Adam, John Henry Anderson, Samuel James Manson Auld, Frederic John Bayley, Gilmour Erving Brown, John L. Chaloner, Edward Houghton Fry, George Maurice Gibbins, George William Edward Gibson, Major Thomas Dalby Hutchinson Hackett, Charles Pollard Hammond, William Howard Head, Francis Eliot Howard, Rudolf Lessing, Joel Abraham Miles, Roderick Harry Parnell (transference from Associate Member), Hugh Pearson, George Frederick Robertshaw (transference from Associate Member), and Dr. Ferdinand Bernard Thole (transference from Associate Member).

As an Associate Member :—Launcelot Owen (transference from Student).

As a Student :—Arthur Walter Cox.

The President said Mr. Ashley Carter had been helping the Institution in a double capacity ; he had been collaborating with Mr. Ockenden in the paper that was to be read and working very hard organising the Dinner, and he understood that Mr. Ockenden would read the paper and Mr. Ashley Carter would for the moment be a listener. The members would remember the previous paper dealing with tools for the percussion system, and the present paper was a supplementary one ; so that the two papers would practically cover the whole ground in reference to drilling tools.

Plant used in the Rotary System of Drilling Oil Wells.

By Maurice A. Ockenden, F.G.S., M.I.Mech.Eng., *Member*, and Ashley Carter, A.M.I.Mech.Eng., *Member*.

Introduction.—In the search for petroleum, the geologist and engineer must co-operate to a greater extent than in the past. Both have to work under difficulties, which are not generally appreciated. The uncertainty or risk in drilling wells, especially

with the ever increasing depths, should be an inducement for enterprising engineers and geologists to take greater interest in the exploitation of oil. As water is the enemy of the petroleum prospector, the engineer adopts methods which increase the difficulties of the geologist. The object of the driller is to "make hole" as rapidly as possible, because to drill by slow methods requires several years' work, and an excessive use of pipe. (Early Russian methods give ample proof of this.) On the other hand, the geologist desires the fullest information of the formation penetrated, but cores cannot be obtained economically as in drilling for coal, minerals, or even for water supply. The absence of fossil evidence increases the difficulty of the determination of geological position.

The art of rotary drilling is young compared to percussion drilling, but it must not be inferred that it is still in the experimental stage.

It has frequently been stated that no special skill is required to operate the rotary, the reason for this being the fact that the drilling tool clears itself, as the drill-stem is lowered into the beds, by the mere releasing of the control on the draw-works, particularly when there are no hard strata to be encountered. Even if more skill is needed for deep borings by percussive methods, with the greater hazard, there is yet much to be learned regarding rotary drilling.

There is still some confusion amongst British and European engineers in the use of the word "rotary." For many years past *core drills*, used with chilled shot and serrated shoes, have been known as the *rotary* system. The unexpected results obtained by the introduction of mud-flush, in place of that with clear water, brought about the general use of rotary tools for drilling through sands, clays and formations of a caving or friable nature. In other words, there resulted a non-coring drill on the core-drill system. Water-well drillers in this country still speak of their core-drilling equipment as "rotary." It is unwise to use mud-flush in connection with drilling for the supply of water, where the free inflow of water is desired, whereas water must be excluded in drilling for gas or oil.

Drillers, properly skilled in any system of drilling, particularly hydraulic rotary, should seek experience in various fields, and so acquire a knowledge of more than one geological area. It is reasonable to suppose that, as more men become skilled by varied experience, and expert in the handling of long strings of pipe, both drill pipe and casing, that the hydraulic rotary will be more extensively adopted, either in combination with percussion tools, or as rotary only.

For unconsolidated sands, gravels and clays with thin layers of sandstones, and, what drillers term, "shell" conglomerates, the

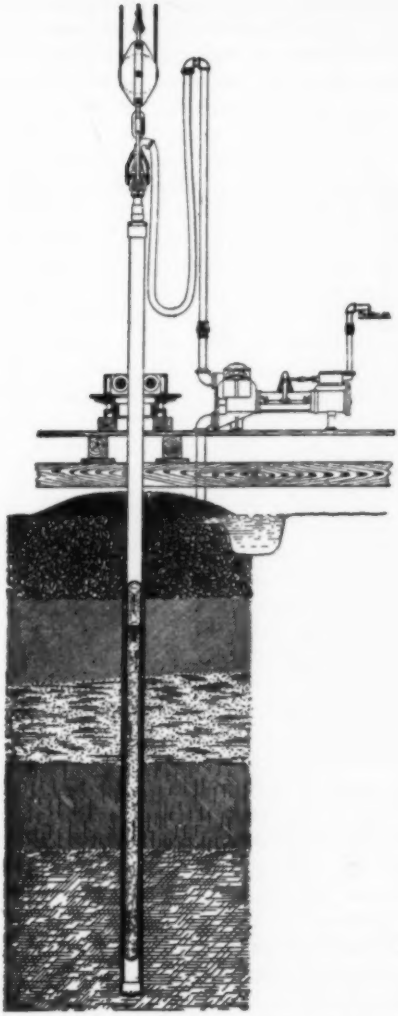

FIG. 31.—Mud flush rotary method, prior to 1910. Note roller grip rings.

rotary can be satisfactorily used, but cemented or indurated formations are not suitable for the plain rotary, as it is now used in the oilfields. It is claimed, however, by enthusiastic rotary operators, that with special tools having a grinding, milling, or abrasive action, harder rocks can be penetrated more successfully, and so allow the use of the rotary tools throughout, without percussion-methods, but as this milling and grinding method is at present costly and slow, it is not universally considered desirable. These special tools can be hired or rented in the American fields, as and when required, and a large initial outlay in plant is thus avoided.

Geologists have good cause to complain of the meagre information obtainable by modern rapid methods of drilling. In penetrating an exceptionally hard stratum—or what drillers call "hard shell"—the depth or thickness can be accurately logged. An experienced Californian engineer writes that when operating with the rotary through either water or oil-sands, the driller may only know of the existence of such beds provided they are at least 10 ft. in thickness, and that gas-bearing strata are only known to exist, when much gas is present. The presence of gas is shown by bubbles or froth in the returns, according to the pressure. For instance, in from 5 to 10 ft. of oil-bearing sands, if not very rich in oil or gas, the existence of such a bed would be very difficult to record, and, consequently, might not appear on the log. The presence of oil is shown by its floating out with the slurry or mud-laden fluid, and as drilling continues throughout the night (it is essential that drilling should be continuous) the difficulty of keeping a correct log is obvious. Exactly where the oil-sands commence would not be properly indicated as in the case of drilling a "dry" hole with cable tools, where there can be constant examination of the contents of the bailer.

Far too little attention is paid to logs. Some uniform system of keeping logs should be in vogue. The absence of suitable terminology is deplorable. One point of difference in logs is colour; e.g. in cable drilling (the so-called "dry" system), drillers make mistakes in classifying the material when wet. Grey material when wet is blue and brown, and bluish shales when wet are nearly black. By drying the material the true colour appears. With the rotary mud-flush, the returns are, of course, discoloured by contact with the mud mixture forced down by pumping. Even sand is affected in this way.

The importance of using mud-laden fluid where gas and water are encountered cannot be over-estimated. It not only greatly reduces the danger to the workmen, but effects a saving in the

amount of casing needed, and eliminates entirely the waste of gas while drilling is in progress. Furthermore, destructive fires due to ignition by lightning of escaping gas is prevented.

The following is an illustration (Fig. 32) of the advantages of the hydraulic rotary in drilling through soft and caving beds where pole and freefall tools failed. In the early part of 1914, the Russian

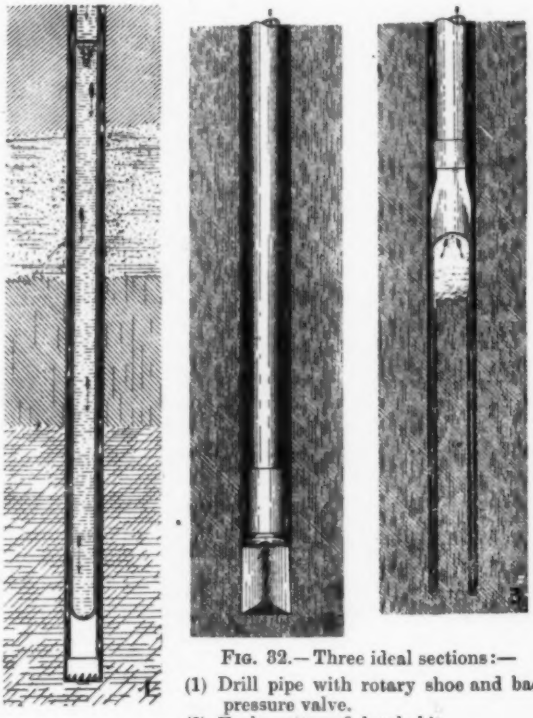

FIG. 32.—Three ideal sections:—
(1) Drill pipe with rotary shoe and back pressure valve.
(2) Early pattern fish tale bit.
(3) Core drill (chilled shot).

Nafta Company in the Surakhany field installed a hydraulic rotary machine. It was placed over a well, which had been abandoned at a depth of 1,794 ft., after eight years of drilling and fishing by Russian systems. This rotary expeditiously drilled the abandoned well to a depth of 2,390 ft. and finished with 6 in. casing, bringing in one of the finest producing wells in the Surakhany field. This

particular machine had previously drilled a well to a depth of 1,400 ft., in less than a month, only using two strings of casing. After the water was shut off with the second string, the larger diameter was withdrawn for use elsewhere, and this 1,400 ft. of drilling was completed with one string, which was something unprecedented in the Baku field at that time.

History.—The modern hydraulic rotary system has been evolved from the water-flush percussion method.

The outstanding features in the evolution of the Rotary System are as follows :—

1846—Beart (English engineer).	First used or invented water-flush method (percussion).
1874—Fauvelle (French engineer).	First used water-flush for drilling for oil, but only with percussion tools.
1875 (about)—Diamond drill.	First introduced. (Brazilian carbonado, a black imperfect crystal, but harder than the crystallised diamond, was discovered in 1843.)
1895—Chapman's horizontal rotary.	First used with rollers for gripping and allowing free movement downward of the casing water-flush only (artesian wells).
1899 Mud-flush with rotary.	First well drilled by mud-flush with rotary (artesian wells).
1900-1—Lucas well.	Col. A. F. Lucas' well drew public attention to the rotary for the Texas field.
1910—Rotary and mud-flush.	Rotary with mud-flush adopted as standard method for drilling through loose formation and, particularly, with heavy gas pressures.

In order to save loss of time caused by the removal of detritus from the well, the system of water-flush drilling was, apparently, invented by Beart, an Englishman, who conceived the idea that by causing a current of water to be kept in continuous circulation from the surface of the ground to the bottom of the well and return, the detritus would be automatically carried away. The first such percussion plant was manufactured by Fauvelle for boring an artesian well at Perpignan in 1846, which was successfully carried out, boring to a depth of 557 feet being completed in fourteen working

FIG. 33.—Surakhany, Russia. Well drilling by Russian methods, completed with hydraulic rotary. Note heightened derrick.

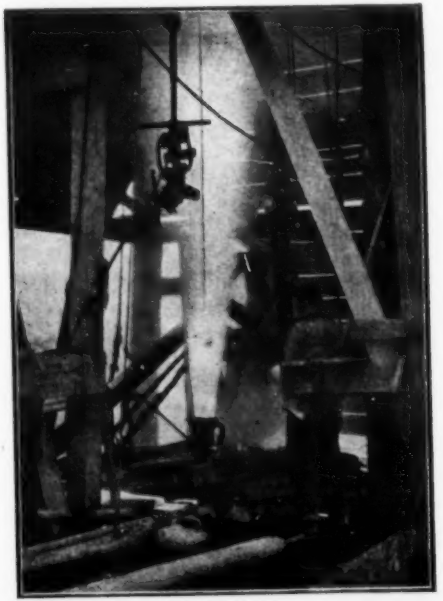

FIG. 34.—Natural gas escaping from a well drilled by cable tools, ultimately controlled by mud fluid, by means of a lubricator. (See Figs. Nos. 39 and 40).

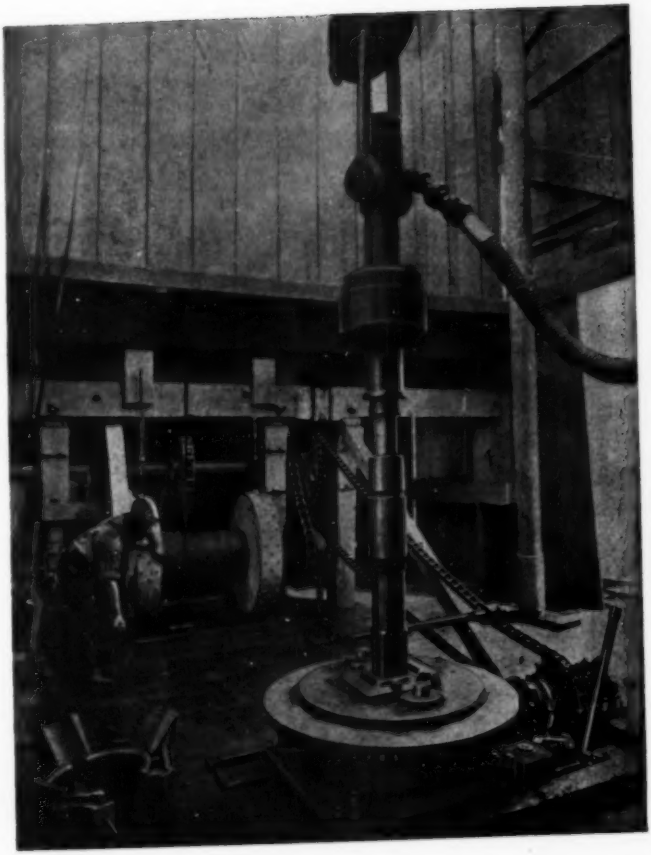

Fig. 35.—Interior view of Derrick. Extra heavy rotary outfit.

days. This was considered remarkable, and even compares favourably with present-day practices. The iron casing consisted of pipes of small diameter. At the outset, ordinary gas-pipes were used, but these soon burst, especially at the joints. Special drill-pipes were made, having a thickness of about $\frac{2}{16}$ in. with a diameter of about $1\frac{3}{16}$ in. the total diameter thus being $2\frac{5}{16}$ in., but it was not until steel pipes made their appearance in 1876, that success was obtained, and fractures considerably diminished. The Fauvelle system was introduced into Baku in the early 'eighties by Nobel Brothers. Four deep wells at Balakhani were drilled, and an experimental well at Zykh. It should be noted that after every 2 ft. of drilling, time had to be allowed for the water to wash away the débris. From this, it would appear that the jetting bit was allowed to plunge into the débris, and so prevent the continuous flow of the water-flush. The foreman driller (a Finn) declared that he could not work so fast at shallow depths with this system (Fauvelle) as with a rope drill (presumably freefall), but found that the Fauvelle system was superior at great depths. This is interesting as showing that if the tools had been rotated, instead of using the percussive jetting method, better results would probably have been obtained.

At about this time (1875), diamond drills came into use. It is interesting to note that the Brazilian carbonado, a black imperfect crystal, but harder than the crystallised diamond, was discovered in 1843. The method of rotation for the diamond crown is similar to the present rotary. Whilst the diamond crown has been, and is still being, used to produce cores through difficult formations, and even of such friable material as coal, it is quite impracticable to utilise this method to drill for oil, because of the free necessary use of clear water.

About 1895, the hydraulic rotary turn-table was designed for drilling through loose sands and clays, particularly artesian wells, along the banks of the large American rivers. This rotary was fitted with rollers which, whilst gripping the casing (not drill-pipe), allowed the free movement downwards as the drilling bit progressed. This system, it must be noted, was a jetting tool on the Fauvelle system, but with the rotation of casing.

Drillers in Pennsylvania, Virginia and other parts of the United States, skilled in the use of cable-tools, found their methods quite unsuitable for the sands and clays of Texas. The first successful well, a gusher, completed in the Beaumont field in January, 1901, was put down by Colonel A. F. Lucas. Evidently, Colonel Lucas was impressed with the rapid drilling of artesian and water-wells

in the Southern States, where wells could be put down with ease in a few hours by rotating the casing, as well as rotating the drill pipe, although most of the artesian-well drilling at that time was practically on the Fauvelle system of jumping or jetting with rotation of the casing only—a combination of percussion and rotary. This first gusher was about 1,300 feet deep, 8 in. and 6 in. casing and 4 in. drill pipe being used. When the oil and gas were reached, the drill pipe was blown out and carried away the crown block off the top of the derrick, the drill pipe following until it was removed from the well, the falling sections remaining fast in the ground where they fell. The flow of oil reached an altitude of between 140 and 160 feet, giving over 20,000 barrels per day, until the flow was controlled.

Mud-laden Fluid.—The action of clear water is sometimes impracticable and always undesirable. Clear water in an unlined borehole usually causes caving by solvent action, and its use not only invites trouble to the driller, but injures producing sands. The value of clay-laden water, which is spoken of more commonly and referred to in this paper as "mud-laden fluid" has been known for some years.

I. N. Knapp writes in 1915 on the use of mud-laden water: "The mixing of clay with circulating water for sealing porous strata in drilling wells is mentioned on p. 167 of Bulletin No. 212, U.S. Geological Survey (issued 1903). This is the earliest written mention I find of the use of mud in any kind of drilling. It was no doubt noted early in drilling by the hydraulic rotary method that after going through a sand or porous stratum and entering clay, such porous material was rendered impervious by the clay cuttings; also that caves in sand were built up and plastered over by such cuttings. The use of mixed mud appears to have had a gradual introduction during the past twenty years, and is not the invention of any one in particular."

The great wastage of gas, particularly from the deeper sands, and, of course, the hazard as regards risk of fire, compelled the Government officials of the U.S.A. to bring forward the advantages of mud-laden fluid, not because of the rapid means of making the hole, but for conserving gas where oil was required from lower levels. Mud-laden fluid is a mixture of water with any clay that will remain suspended in water for a considerable time. There have been several statements made by engineers as to its preparation, but I. N. Knapp suggests that such a mixture may weigh 33 per cent. more than the same volume of clear water, or give a head of 57 lbs. per 100 ft., an increase of, say, 14 lbs. on each 100 ft. of depth, but

heavier or lighter mixtures can be used. That mentioned was found to give good average results. One clay will settle in a week: another form will take six months before the water will really

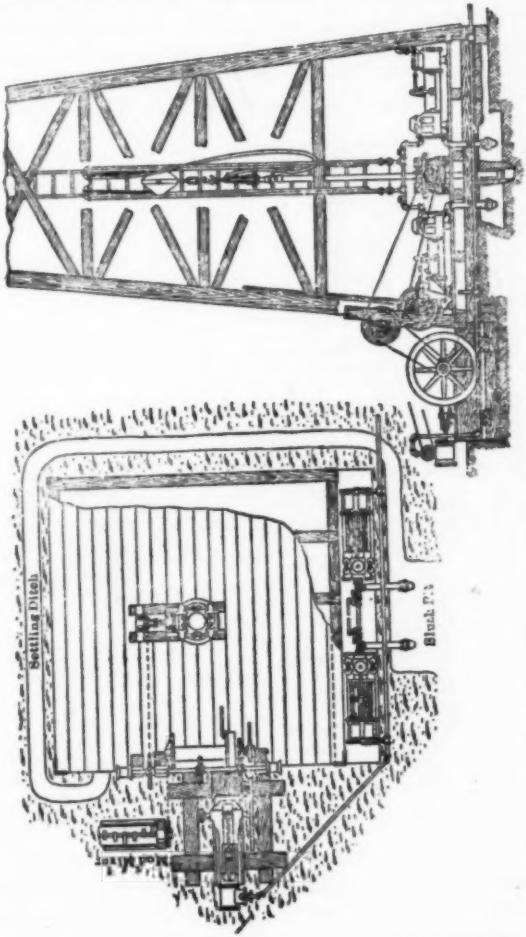

FIG. 36.—General arrangement of hydraulic rotary drilling (U.S. Geological Survey).

become clear. The question has been asked what kind of clay or mud can be used, but it is difficult, apparently, to make any suggestions as it is only by demonstration or testing with local

material, or importing most suitable material at the minimum expense that a conclusion can be obtained. A. G. Heggem claims that any clay free from grit will serve to make mud-laden fluid, and that the best muds are generally obtainable from the shales encountered in drilling. The clay can be washed from the sand and a sufficient supply for all needs will be at hand, if a proper sump hole is prepared to retain the sand pumpings. In the *U.S. Bureau Mines Techn. Paper* No. 66 (Pollard and Heggem), the

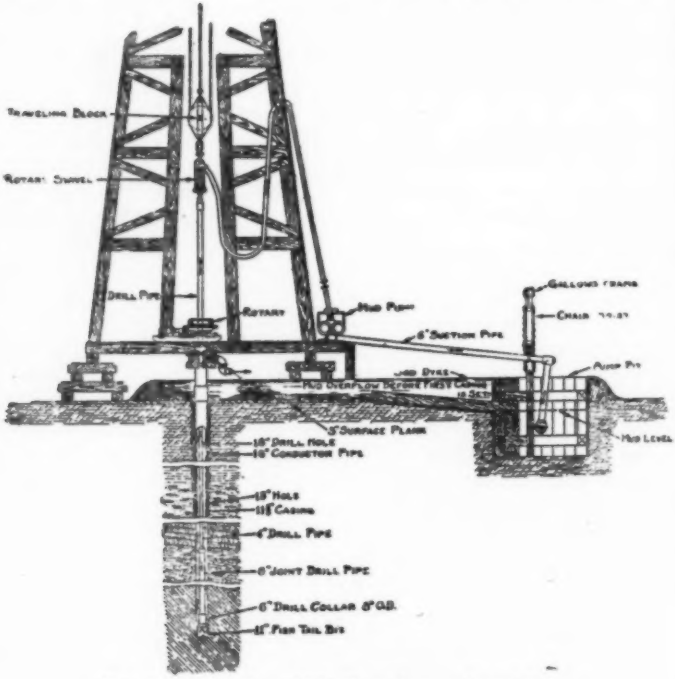

FIG. 37.—Elevation of Mr. Knapp's experimental rig.

proportion of clay that should be mixed with water to ensure the best results, is given at about 20 per cent., as it is claimed that, however experienced a driller may be, he would not know, and could not tell, whether there was any clay in the hole, because tools would work with the same freedom as with clear water. The distance to which clay in suspension will penetrate the porous formation depends upon the pressure produced by hydrostatic

head, and that of the pump used during drilling, also upon the porosity of the formation. Very few wells can be filled with clear water, because of the porosity of the sand or rock, and where drillers have attempted to shut off gas with the use of clear water, good gas sands have been permanently drowned, and, of course, the use of clear water has produced a caving of the walls of the bore-holes with the inevitable "freezing" or seizing of the casing. The clay in suspension enters the porous stratum under pressure

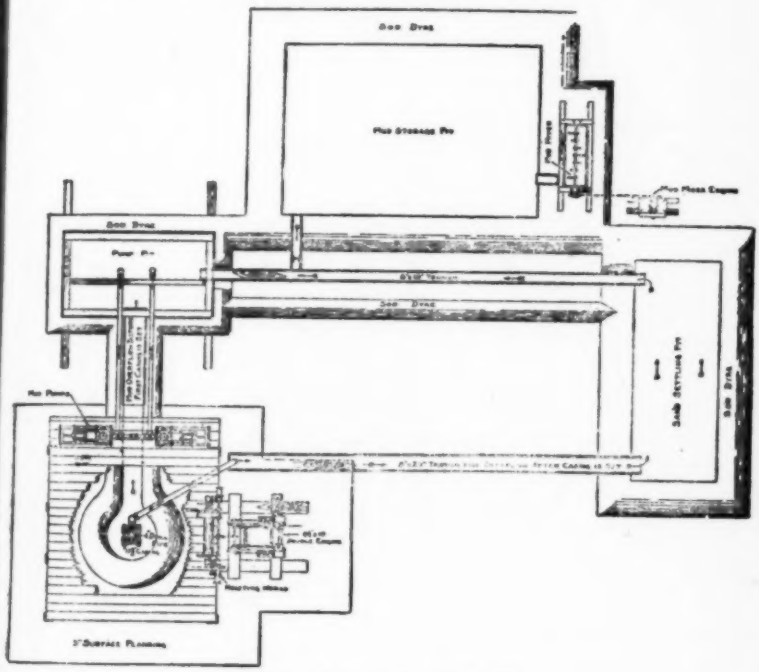

FIG. 38.—Plan of same rig (Fig. 37)

by pumping for a short distance, and by depositing the clay, clogs the openings and prevents further inflow of the fluid. It is claimed (Pollard and Heggem) that gas-bearing beds can be sealed or unsealed as desired. Should it be necessary at any time to recover gas from a porous bed that has been clogged or sealed by mud-fluid, the bailing out of the fluid to a level where the hydrostatic pressure on the sands at the bottom is less than the gas pressure will allow the

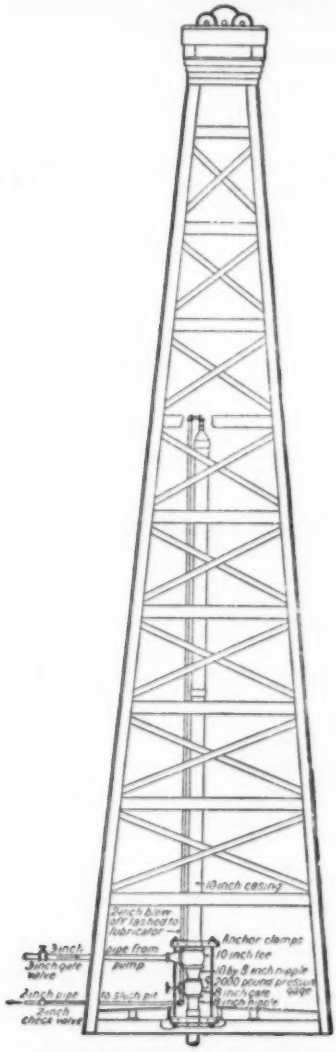

FIG. 39.—"Lubricator," a device for introducing mud laden fluid under heavy natural gas pressure. (*U.S. Bulletin* No. 134).

remaining fluid in the bottom of the well to be forced out by the superior gas pressure, and the gas sand will be thoroughly cleaned of the clay deposit.

It is necessary to maintain a circulation of mud-laden fluid of

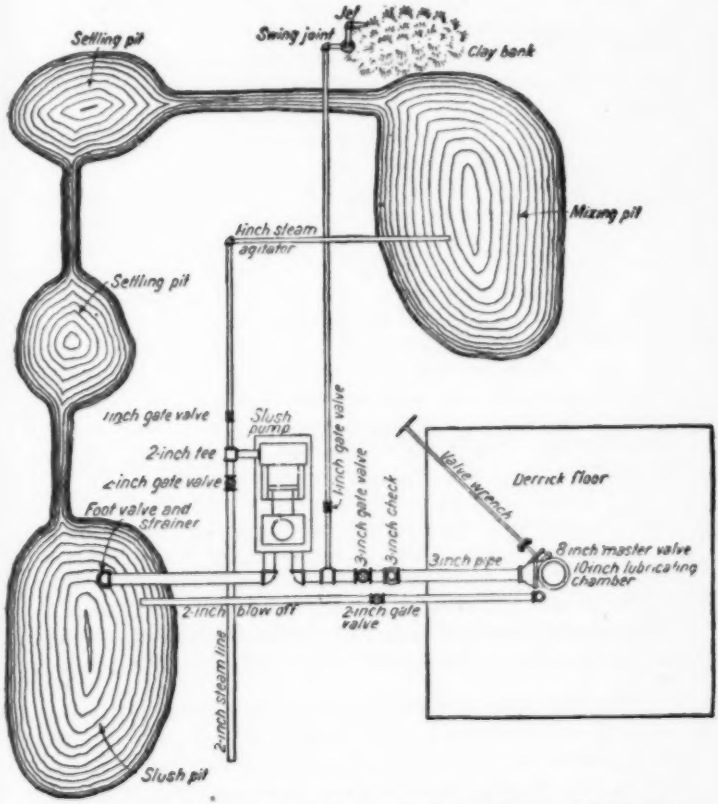

FIG. 40.—Ground plan of equipment used in handling mud laden fluid. (*U.S. Bulletin* No. 134).

such consistency as will resist erosion of the weakest sand stratum to be encountered. In drilling there is always an increase in the weight of the mud-laden fluid, as the drilling progresses, which can be rectified by the addition of clear water in the circulation.

Rotary Systems comprise :—

(*a*) Diamond Core drills
(*b*) Chilled shot „ } water-flush.
(*c*) Circular tooth cutters
(*d*) Circular cutters and bits for mud-flush.

As cores cannot be obtained without water-flush, the rotary system as applied in the oilfields is confined to mud-flush.

The choice of any drilling system depends principally upon geological factors, and this is particularly true regarding hydraulic rotary.

The principal objects in drilling a well are :—

(1) Location of well site to obtain oil.
(2) Diameter of bore-holes, to maintain a suitable diameter for production at depths in excess of first estimates.
(3) Speed of drilling. To drill rapidly and economically.
(4) Exclusion of water. To effectually and permanently exclude water.

(1) The selection of a site is usually arranged by the geologist and consulting engineer. Much depends upon the manner in which the driller *plans* his equipment, particularly the arrangement of the mixing pit, the ditch with its settling pond, and the sludge pit ; also arrangements for supply of water and clay. Again, much depends upon local conditions, subsoil, contours, etc., but the usual arrangement is as shown in Fig. 40.

(2) Assuming a regular hydraulic rotary outfit is to be used, a 2,500 ft. bore-hole could possibly be finished with two strings of casing, although four strings of casing might be required, commencing not less than 12½ in., in which case the diameters would be 12½ in., 10 in., 8¼ in. and 6⅝ in. Needless to say, the object of the driller should always be to keep the bore-hole diameter as large as possible, especially in a field which has not been fully tested for deeper seated oil sands.

(3) Sands, clays and shales are drilled rapidly with the rotary system. It is possible to drill or wash through sand with mud fluid 100/200 ft. a day (24 hours). Whilst drilling in clays and shale, the swelling, which is so troublesome in dry percussion methods, is minimised by the constant flow of the mud fluid from the pump. 300 ft. in 24 hours is not uncommon and 200 ft. per day is frequently recorded in clays and shales. Such footage, of course, can only be maintained by the use of good quality bits, which are not unduly affected by wear, as in the case of clays, but, in drilling through sands, wear on the bits is considerable, so that the tools have frequently to be withdrawn for " dressing " and change.

Abnormal speeds are not advocated by experienced drillers, who do not attempt to break records in fast drilling, and risk the unnecessary wear and tear of the drilling plant. The authors submit that it is undesirable to encourage excessive speed and so risk ineffectually sealing the inflow of water, as the extra speed of drilling limits the deposit of clay.

(4) The subject of effectually excluding water by the use of mud is referred to in another part of this paper. The setting of casing in a bore-hole is of primary importance. Some strata can resist

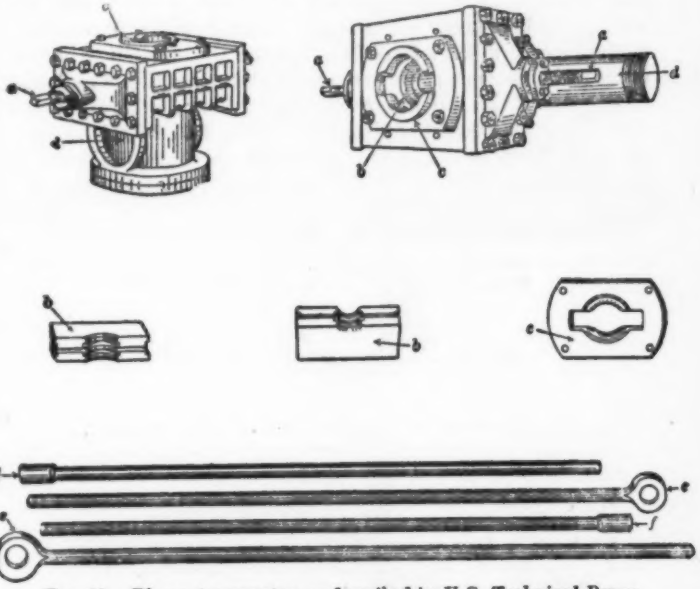

FIG. 41.—Blowout preventer, as described in *U.S. Technical Paper* No. 42 (Bureau of Mines).

less than others. Hager states that "soft sands and shales are more subject to change due to compressive action than are sandstones and limestones. Shales and sands creep or shift under compressive power that would not noticeably affect harder formations. Folds furnish excellent conditions for unbalanced pressures and consequently, when drill holes which disturb the equilibrium of a series of pressures are put down, collapsing of the casing or caving of the open hole results. . . . Even at a few hundred feet, pressures of 300 to 400 lbs. may cause the formations to cave or

to creep into the drill hole." Whilst the bore-hole may appear to be free during the progress of drilling, good casing should be permanently placed to allow for subsequent earth movements which cannot be anticipated by the driller.

The Circulator, or circulating system, is a method of drilling illustrated in Mr. Calder's paper, Fig. 38, Vol. 1, page 249. This is essentially a mud flushing process, in combination with cable tools. The fluid is forced through the casing during drilling and returns between the casing and the wall of the bore-hole, so that theoretically casing does not come into contact with the wall of the bore-hole. There is the danger, however, in using this method (dealt with in Bulletin 134 of the U.S. Bureau of Mines), of the casing becoming *frozen* or seized by the deposition of sediment on one side of the bore-hole caused by the fluid flowing through a water course or channel as illustrated in Fig. 42. By this system, the casing has been carried down to exceptional depths in California, in one instance, 10 in. casing was lowered 3,336 ft. in 122 days.

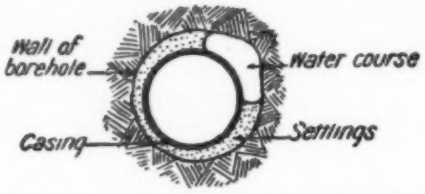

FIG. 42.—Cross section of well (*U.S. Bulletin* No. 134).

Essential plant in a Rotary outfit:—

1. derrick; foundation and base.
2. rotary machine; grief stem.
3. hoist or draw-works; crown block.
4. machinery; engine and boiler; transmission.
5. mud pumps; manifold; mud mixer.
6. swivel; hose.
7. drill pipe; tool joints.
8. cordage.
9. drilling tools; bits and cutters; drill couplings.
10. fishing tools.
11. tools for handling pipe; ring and wedges; elevators, tongs, travelling block, "C" hook.
12. miscellaneous (or extras as necessary); blacksmith's tools; carpenter's tools and sundries; water supply; electric lighting plant; rig housing.
13. fittings (boiler and engine).
14. pipe; casing.

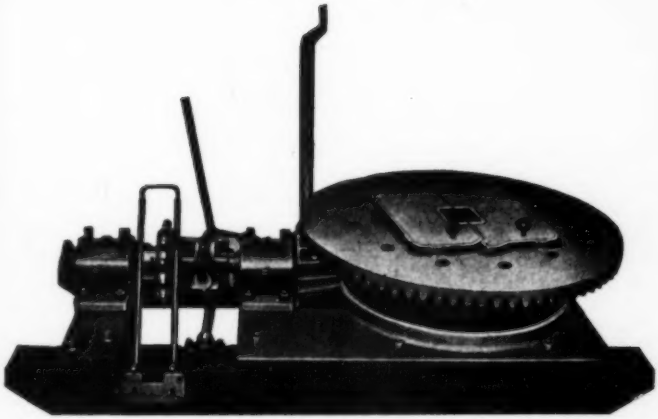

FIG. 43.—26 in. Steel Rotary, showing drive ring bushing for grief stem.

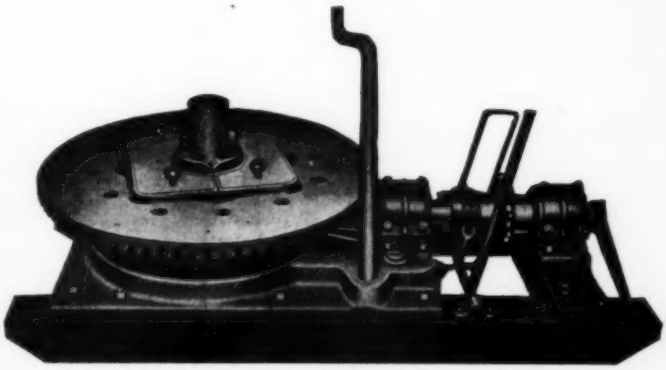

FIG. 44.—26 in. Steel Rotary with spider and slips for holding pipe in suspension.

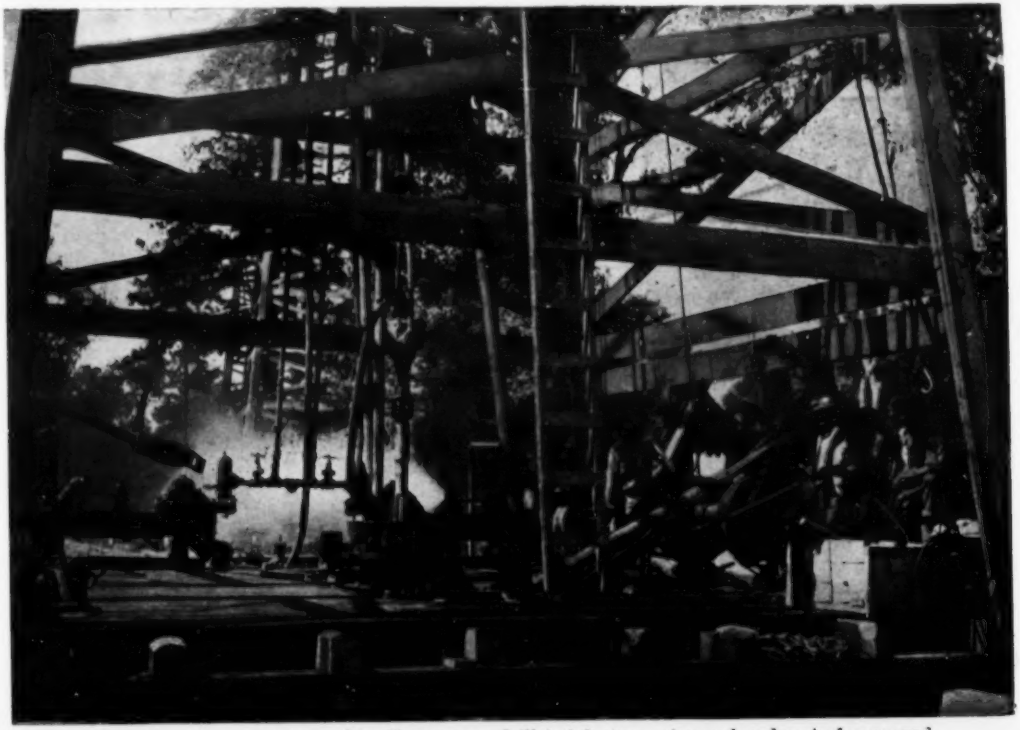

FIG. 45.—Heavy rotary outfit. Note square drill (grief) stem; ring and wedges in foreground to grip round rotary pipe.

Derricks.—The subject of derricks was fully dealt with by the authors in their paper on plant used in the percussion systems. The outstanding features of the rotary derrick are the additional height, according to the depth of the wells; draw-works posts, and the "V" side of gap, to give accessibility to long strings of drill pipe and casing. Derricks for straight rotary drilling have five-pulley crown blocks.

Rotary machine.—The hydraulic rotary, as now designed, is provided with a rotary table with suitable lubrication arrangements. The pinion shaft bearing boxes have been strengthened and the whole machine should be constructed of steel. Transmission is by chain drive with suitable clutch. The latest pattern rotaries are fitted with drive ring bushing, with grips for rotating the grief stem, and a further bushing is inserted, which acts as a ring and wedges (spider and slips) for the regular drill pipe as it is removed from or lowered into the well. The earlier forms of rotary were provided with grip rings for rotating the casing and later the drill pipe, which, however, became damaged by the sharp edge of the rollers gripping, to such an extent that it was found a serious and costly defect, the result being that the grief or drill stem was introduced. This stem has either a square or octagonal exterior surface, fluted cross section or wings. A grief stem, 30 to 45 ft. long, weighing up to 4,000 lbs. is frequently used. It is wise to have ample length of stem, so that when pumping ceases for attaching additional 18 to 20 ft. lengths of drill pipe, the lower portion in the bore-hole can be raised above the bottom of a treacherous unlined bore-hole. The grief stem should be made of a solid forging and drilled through the entire length, thereby eliminating welds. The square or octagonal grief stem is much stronger and more positive in action than the fluted or winged type, owing to the greater area of driving surface.

Hoist or draw-works.—With the greater depths to which wells are now drilled, the draw-works have undergone considerable change in their construction and capacity to meet existing conditions. Their function is that of transmission of power to the rotary table, to carry and lift the entire string of drill pipe and to operate the casing line. They are placed on the engine side of the derrick and consist of a steel line or countershaft, the diameter of which is up to $4\frac{7}{8}$ in., carried by brackets, bolted to the outer side of the three draw-works posts. On the countershaft are keyed the engine drive sprocket (through which motion is imparted by the engine) high and low speed drum drive sprockets, and drill drive sprocket, while at either end cat heads (winches or nigger

heads) are keyed on to facilitate the starting of breaking or unscrewing of the tool joints. A drum shaft clutch is provided to allow of the countershaft running free and alternatively when operated, to impart motion to the drum shaft. On the drum shaft are provided high and low speed clutches, sprocket wheels and a hoisting drum on which is coiled the wire rope for operating the travelling block. The drum shaft is supported by brackets, bolted to the inner side of the three draw-works posts. The object of providing three brackets on the draw-works posts for carrying the countershaft and drum shaft is to give the necessary rigidity. Two powerful brake bands, with asbestos composition brake blocks, control the hoisting drum. The brake band, clutch levers and telegraph wheel are arranged for convenient manipulation. The weight of draw-works of the heaviest construction, such as are above described, run up to 13,000 lbs. (5¾ long tons), as compared with the earliest pattern with single brake (1¾ tons).

Machinery.—The engine and boiler were dealt with in the author's paper (Vol. V). For the hydraulic rotary system, the engine is operated by chain drive, in place of belt drive, and as the load is more uniform, balance rings are not used on the flywheel as in percussion outfits. Ample steam reserve must be provided because of the possibilities of an unexpected demand for steam for the mud pumps, in addition to the requirements of the draw-works when both working at their full capacity.

Mud Pumps.—The sudden cessation of pumping from any cause, particularly during drilling through caving beds, necessitates provision for two pumps in every outfit, fitted with manifold, valves, pipes and fittings, so that, in the event of failure of one from any cause, the other may be put into operation. The pumps for dealing with the mud-laden fluid are of duplex double-acting type and have been frequently increased in size until, in present day practice, steam cylinders of 12 in. diameter and water cylinders of 6¾ in. diameter, with stroke of 14 in., are commonly used. Their capacity is 8·675 gallons per revolution, suitable for work against high pressures.

Swivel.—The swivel is an important factor. A well-designed swivel should have a good oil-bath, ball bearings and roller bearings of tool steel, to ensure absolute delicate rotation of the drill pipe to prevent accidents with the hose, also to positively exclude from working parts all water or mud fluid. Should the hose become detached or fouled by defective swivel, the flow of fluid being suddenly shut off from the drill, settlement of detritus and mud may seize the bit and cause a "twist off."

Drill Pipe.—Cables of the percussion drilling plant and drill pipe of the hydraulic rotary are perhaps the most abused units and are responsible for most fishing troubles. Too heavy a load, or too fast a speed of the drill pipe are the causes of most fractures. Pipe lowered too rapidly is likely to follow the line of least resistance and crowd off into the softest formation, resulting in a crooked hole. The drill pipe in most general use is of 4 in. or 6 in. diameter, the former usually weighing 15 lbs. and the latter 29 lbs. per ft. The larger size is used in casing down to 8¼ in.

As showing the development of drill pipe, this interesting subject was summarized by Mr. Charles D. Terry before the Engineers Society of Western Pennsylvania, who stated that "with the rotary drilling method, there had been waged a never ceasing battle between the drilling machine, as represented by the driller on one side, and, on the other side, a drill stem made of pipe. First,

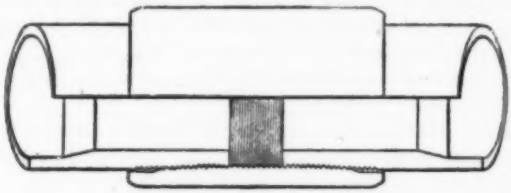

FIG. 46.—Upset rotary drill pipe.

ordinary standard pipe or line pipe was used, and if the strain imposed by rapid feeding downward, or encountered by reason of a hard stratum, was too great, the drilling machine broke. The builders of the machines strengthened them until it was the drilling stem of pipe and not the machine which gave way. Then heavier pipe with longer threads and stronger couplings came into use and the drilling machine was again defeated. After being designed on still sturdier lines the machine was victorious. Then there came the use of a novel coupling or joint. With threaded tubular material the area of metal in the cross section at the bottom of the threads is, of course, less than in the unthreaded portion of the pipe. Consequently, with a destructive torsional strain, the material twisted off at the threaded portion. To overcome this, the pipe, before threading, is upset so that the area of cross section below the bottom of the threads is fully as great as that of the unthreaded portion of the pipe." The threading of the drill pipe is preserved and much time saved by the use of rotary tool joints, which are specially forged couplings inserted in the string of drill pipe, wherever it is necessary to make or break joints.

The advantage of the upset in pipe is plainly evident from torsional tests on 4 in.-12½ lb. rotary pipe. In each test two lengths of pipe were coupled together using various rotary pipe joints, one end being held stationary while the other was rotated until failure occurred. The value of the upset in strengthening the line against torsional strains is shown by the fact that an average of 197,000 inch-pounds was necessary to cause failure when pipe was upset at the joint, while an average of 145,000 inch-pounds caused failure with the *same joint* when the material was not upset.

Considerable care should always be observed in the handling of rotary drill pipe so as to get the best service out of the pipe, save time and expense and increase the life of the pipe. The following is a copy of the suggestions issued by manufacturers for the care of rotary drill pipe.

1. Before the drill pipe is screwed together both the threads on the pipe and in the couplings should be thoroughly cleaned, and a good application of heavy oil or grease (mixed with graphite) applied to each. This will make the joints screw up and part easily, and keep out the sand and water.

2. When screwing the pipe into the coupling be sure that it is properly screwed up before lowering same into the bore-hole. Do not expect or permit the rotary machine to screw up the joint after same has been lowered.

3. When placing a section of the pipe in the coupling do not let the section drop into the coupling. Place it in lightly so that the weight of the pipe will not injure or turn over the first threads. If the first threads are turned over they will be ground into the remaining threads as the joint is screwed up. This causes much difficulty in unscrewing the joint, and ruins the threads on the pipe and in the coupling.

4. When the drill pipe is being pulled out of the bore and the joints unscrewed, the weight of the sections being taken off should be carried on the hoisting lines. This can be easily accomplished by attaching a weight (a trifle heavier than the pipe being unscrewed) to one of the hoisting lines. As the section is unscrewed the weight is taken off the threads.

5. Whenever the drill pipe is being pulled out of the bore-hole it should be washed out with clean water as it comes out. This will remove all mud or sand, and the threads will stay clean when the pipe is standing in the derrick.

6. Do not hammer the couplings very hard. Use a small hammer and tap lightly all round the coupling before starting to

unscrew. Too much or too hard hammering will injure the threads, expand the couplings, and allow the ends of the pipe to creep until they come together.

7. When drilling in hard formations the grip rings on the rotary machine have to be very tight in order to hold the drill pipe securely. The pipe is thus often gouged and bent as it passes through the rotary machine.

A bent or gouged section of pipe should never be used below the rotary machine.

8. To prevent wear and tear on the drill pipe a special grip pipe should be used. This grip pipe is made extra heavy and of sufficient length to drill the hole far enough to permit a new section of regular drill pipe to be put on below the rotary machine.

Elevators.—In the early days of drilling there were many accidents caused by the use of inferior clamps and elevators, with the result that many patents were issued for improvements in double bail types. The rapid drilling by the introduction of the hydraulic rotary method and the need for expeditious lowering and raising of very long strings of drill pipe brought about the single bail type with automatic locking gates. Fig. , illustrates what is at present the fastest and strongest elevator, also giving complete security to operators. One advantage is that this type can pick up pipe from any position without removing the bail from the hook.

Bits.—With the development of the rotary system of drilling, many improvements have been introduced from time to time in the design and quality of material used in the bits. There are two regular types included in all specifications, viz., the fishtail and the rotary shoe. The "fish tail" bit, which is a blade set off in such form as to present two cutting edges, was originally used almost exclusively, and, on account of its relative economy in cost and its suitability for certain formations, will undoubtedly continue to be largely used, although the "fish tail" has been modified, see Fig. 47. Holes are provided at the top of the blade for the free circulation of the mud-laden fluid, which emerges at high velocity in a vertical direction towards the cutting edges. The following are standard dimensions and weights of *long* fish tail bits :—

Extra Long Rotary Drill Bits.

Size Drill.....ins.	6	8	8¼	10	12	12	12	13	14	15	16	18
*Size pipe connections ...	4 in.	4 in.	4 in.	4 in.	6 in.	4 in.	6 in.	6 in.	6 in.	6 in.	6 in.	6 in.
Width of blade	5½ in.	7½ in.	7½ in.	9½ in.	9½ in.	11½ in.	11½ in.	12½ in.	13 in.	14½ in.	15½ in.	17 in.
Length of blade	20 in.	22 in.	22 in.	24 in.	24 in.	24 in.	24 in.	24 in.	24 in.	24 in.	24 in.	24 in.
Length over all	25 in.	27 in.	27 in.	29 in.	29 in.	29 in.	29 in.	29 in.	29 in.	29 in.	29 in.	29 in.
Dia. of water holes ...	¾ in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.
Thickness of blade (top) ...	1½ in.	2 in.	2 in.	2 in.	2 in.	2 in.	2 in.	2 in.	2 in.	2 in.	2 in.	2 in.
Thickness of blade (bottom)	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1⅛ in.	1⅛ in.	1⅛ in.
Estimated weights.....lbs.	112	136	136	168	168	170	176	185	185	278	290	
Width of cutting points ...	5⅞ in.	7⅞ in.	8⅜ in.	9⅞ in.	9⅞ in.	11⅞ in.	11⅞ in.	12⅞ in.	13⅞ in.	14⅞ in.	15⅞ in.	17⅞ in.

* The above bits are furnished with tapered pins threaded, or threaded for drill pipes.
The extra long bits are dressed, and should be carefully tempered before use in the field.

The four-way rotary drill bit is used for reaming out the bore-hole, and, when originally introduced, was made with shank for connection to the drill pipe.

The Diamond bit commonly employed in the early days of the rotary is now used only for side tracking and not for regular drilling.

To secure the advantage of working on the shoulder of the tool joint and eliminating creeping of the threads, causing springing of

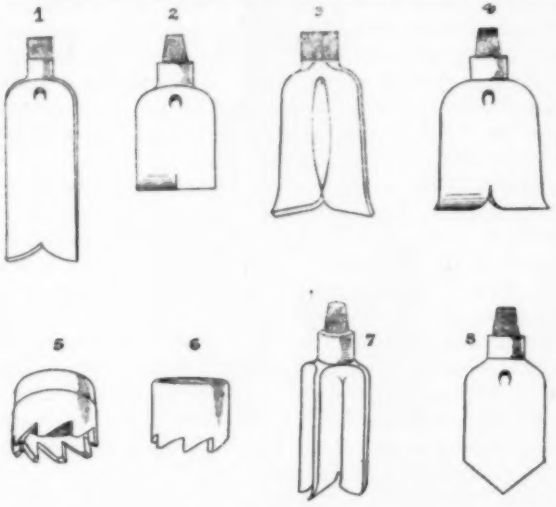

FIG. 47.—Rotary Bits:—

1. Long fish tail—straight shank.
2. Light fish tail, with tapered pin.
3. Medium fish tail—straight shank.
4. Heavy fish tail—tapered pin.
5. Combination rotary and drive shoe.
6. Regular rotary shoe.
7. Four-way bit—tapered tool joint.
8. Diamond bit—tapered tool joint.

the drill collar with the ultimate tendency to stripped threads, bits are provided with tapered pins for connection to tool joints.

A bit which has met with considerable favour in sticky clay, sand and conglomerates, in the Californian fields is the rotary disc bit. It has, to a limited extent, also been used for drilling rocks, but is not suitable for this purpose. Considerable experience and extreme caution on the part of the driller, however, are necessary in the operation of this bit, it being essential that the feed be applied very slowly, otherwise the discs fail to rotate, resulting in uneven wear and decreased speed of cutting. Moreover, as the discs wear out of gauge, causing reduction in the diameter of the bore-hole,

the disc pattern is not now favoured. Disc bits are made in two halves and the discs inserted, a sub or head screwing on to the lower part of the bit.

For moderately hard formations a drag bit is sometimes used. The effect of this bit is to crush or grind with the use of steel grit or—what is termed in America—"adamantine," there being, of course, no core as in the regular chilled shot process.

The cone type of bit, consisting of a body with rotating cones, having a number of cutting faces, giving the effect of a milling tool, was introduced to "make hole" through extremely hard formation, without using shot or grit, but from its somewhat complicated construction is relatively expensive, and not used extensively outside the U.S.A. Lubricating arrangements are provided for the pins on which the cones rotate.

Another cone bit on the revolving disc principle is that known as the roller bit. This is a comparatively new type and the result of its work in U.S.A. fields should be carefully observed. The design of the drill head, which is practically a solid block of steel, is such, that all parts of the bit, except the cutting edges of the rollers, are enclosed and protected. Water courses, giving a double nozzle effect, playing on the top of the revolving cutters are provided, thereby keeping the clearance spaces in the cutter carrying recesses, free from drillings and assisting the water to impinge with great force on the material as it is cut and flush it out. It is claimed that the friction contact of the cutters on the bottom of the hole positively rotates them coincidentally with the rotary movement of the bit. The cutters are made thick and of a special alloy steel. To give an idea of the cutting surface, it may be stated that in a set of 9⅞ in. cutters there are 56 teeth, each 3 in. long. Lubrication is effected by an oil chamber formed in the cutter, having a capacity of several hours' work.

Every drilling bit should be attached to the drill pipe by a steel forged drill collar or coupling, having a pipe connection at the upper end, and tool joint connection at the lower. The couplings vary in length up to several feet, and are of considerable thickness. The object of the long drill coupling is to assist a vertical position being maintained in the event of fracture and thus facilitate fishing operations. In order to make a stiff connection and to prevent a "twist off," they are sometimes provided with a babbitted joint and riveted to the drill stem.

Conclusions.—The object of this paper is to refer to equipment only, but some reference is necessary to methods, particularly in regard to the use of mud-fluid. The hydraulic rotary has, perhaps,

a greater future as an auxiliary to percussive methods than as an independent system, although there are certain fields where the rotary can be used entirely.

Drilling machinery is designed and built in accordance with the

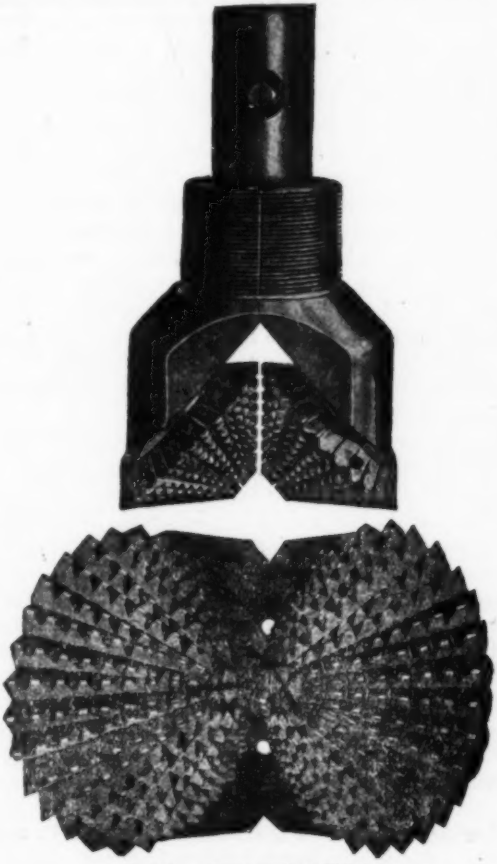

FIG. 48.—Cone rock drill bit.

ever changing requirements of the field, and, as far as it is possible, taking into consideration an extreme conservative factor of safety. Much of the plant receives the minimum of attention, and the duty cannot be definitely anticipated.

Consulting engineers, or those responsible for the supply of material, should scrutinise requisitions from the field, not so much to prevent changes being made, but to prevent unnecessary changes in gauges, threads, etc., particularly for material lowered into the bore-hole. The enthusiasm of the driller-engineer for improvements in one unit may necessitate changes in various items. It may be claimed that, with the hydraulic rotary, a lesser assortment of fishing tools is required, because of the smaller variety of tools or appliances used below the surface of the ground.

Whilst the rotary system is a satisfactory mechanical means of overcoming difficulties, it is not desirable to introduce this method for wild catting or pioneer work, or for geological investigations, but it should often form, however, an auxiliary to percussion tools.

In view of the importance of the early indications of oil and gas, and the meagre geological information available, the driller should not be expected to assume the great responsibility of reporting or expressing an opinion which is frequently accepted. His decision might be misleading and cause heavy expenditure in unnecessary further drilling or abandonment of good producing areas. The duty of the driller is to make a satisfactory well in a reasonable and economical manner.

As the authors remarked in their last paper, there is need for greater co-operation between the geologist (or consulting engineer) and the manufacturer with the field management. Manufacturers of machinery, tools, pipe and all supplies should be held responsible for the quality and construction of material furnished, but not for the manner in which it is used.

An analysis of the drilling systems and usual dimensions, types and combinations of pipe used in the different fields throughout the United States was displayed by the authors at the meeting.

The following is a recent specification, especially drafted for drilling operations in Russia to a maximum depth of 3,000 ft. and to finish with 8 in. diameter hole, minimum. Obviously, it is impossible to include items which vary or are subject to local conditions.

SPECIFICATION.

Hydraulic Rotary (Standard) Drilling Outfit.

(Depth 3,000 ft.).

It should be carefully noted that the following specification for Russia (Baku) includes large diameters of pipe, which are not usual where the finishing diameter is 6 in. Attention is drawn to the size of the engine. Owing to the local laws governing boilers, steam boiler pressure is restricted to 60 lbs. per sq. in.

The authors are under the impression that diameters for the Russian fields will be modified as soon as the rotary has been properly introduced, present conditions favouring large diameters for bailing purposes, which may not be necessary in the future. Furthermore, there will be more economy in casing by the use of the rotary.

Derrick.

Tubular or steel derrick should be provided of 120 ft. in height with 24 ft. base to allow of the largest number of joints of drill pipe to be extracted in one section. Some wells are drilled, however, with a derrick 86 ft. high with 20 ft. base. If timber and lumber are available, and preferred, a specification should be added for construction locally.

Rotary Machine.

1 27 in. all steel rotary machine complete with drive ring, drive ring bushing for 6 in. square forged steel drill stem, also steel spider with slips for 6 in. drill pipe.
1 set slips for spider to catch 4 in. drill pipe.
1 drive ring bushing liner for 4 in. square stem.
1 set grip rings complete.
1 6 in. square × 45 ft. long forged steel drill stem complete with couplings for 6 in. drill pipe.
1 4 in. square × 30 ft. long forged steel drill stem complete with couplings for 4 in. drill pipe.

Hoist or Draw-works.

1 set extra heavy type draw-works complete with three wood posts.
1 set extra heavy head boards for rotary hoist.
1 12 in. heavy structural steel "I" beam crown block with closed bearings and five pulleys.
1 42 in. quadruple bronze bushed all steel travelling block.
1 6½ in. double swivel drilling hook.
1 4 in. new style strapped "C" hook.

Machinery.

1 boiler, loco type, for 60 lbs. working pressure with the use of suitable local fuel.
1 set chain mountings for the above boiler 8 in. tyres.
1 boiler feed pump, 6 in. × 4 in. × 6 in.
1 16 in. × 16 in. drilling engine with 15 in. rotary sprocket wheel, and special Texas fly wheel.

1 set tie rod braces and sockets with bolts and washers for the above engine.
65 ft. 3·9 links per ft. steel sprocket chain.
35 ft. 3 links per ft. steel sprocket chain.
85 ft. malleable sprocket chain for mud mixer.

Mud Pumps.

2 12 in. × 6¾ in. × 14 in. heavy mud or slush pumps with air chamber.
1 manifold for mud or slush pumps (interchange valve control).
1 set castings and sprockets for mud mixer.

Swivel.

2 6 in. oil bath loose bail swivels.
2 4 in. „ „ „ „ „
2 pieces 2½ in. six ply special wire-wound rotary drilling hose, each piece 32 ft. long, complete with connections to swivel and stand pipe.
1 piece 1 in. four ply × 25 ft. derrick hose complete with 1 in. pipe connections.
2 6 in. × 4 in. forged steel bushings.

Drill Pipe.

ft. drill pipe
(*a*) Diameter
(*b*) Weight
(*c*) Material
(*d*) Type of joint
} *Details according to local conditions.*

6 in. × 18 in. long tool joints, 5 in. × 6 in. × 4 threads
4 in. × 18 in. „ „ „ 3 in. × 4 in. × 7 „

Cordage.

1 1 in. × 1,100 ft. wire casing line for hoist.
1 $\frac{9}{16}$ in. × 3,500 ft. wire sand line.
1 1¼ in. × 250 ft. manilla cat head line.
1 15 lbs. sucker rod hook for cat head line.

Drilling Tools.

2 4 in. × 18 in. drilling couplings, one end threaded for drill pipe and other end for 3 in. × 4 in.—7 pins.
2 6 in. × 18 in. long drilling couplings, one end threaded for drill pipe, and other end for 4 in. × 5 in.—7 pins.
1 6 in. × 18 in. long drilling coupling, one end threaded for 6 in. drill pipe, and other end for 3 in. × 4 in.—7 I. & H. pins.

2 26 in. fish tail bits 4 in. × 5 in.-7 pins.
2 24 in. „ „ „ „ „ „
4 22 in. „ „ „ „ „ „
4 20 in. „ „ „ „ „ „
6 18 in. „ „ „ „ „ „
8 14 in. „ „ „ „ „ „
8 10 in. „ „ „ 3 in. × 4 in.—7 pins.
8 8 in. „ „ „ „ „ „

NOTE.—The above bits according to diameter of casing used. Also joints straight or tapered.

Fishing Tools.

1 6 in.-8 thread male and female forged steel die nipple.
1 4 in.-8 „ „ „ „ „
1 6 in.-8 thread steel rotary shoe
1 8 in.-8 thread „ „ „
1 6 in. wash down rotary trip spear complete with jars and sinkers, also one extra set slips.
1 4 in. wash down rotary trip spear complete with jars and sinkers, also one extra set slips.
1 overshot to run on 6 in.-8 thread drill pipe to run over and catch 4 in. drill collar.
1 overshot to run on 10 in.-10 thread casing to run over and catch 6 in. drill collar.

Tools for Handling Pipe and Casing.

1 set 4 in. Mannington pattern elevators, $1\frac{3}{4}$ in. × 28 in. links.
1 set 6 in. „ „ „ 2 in. × 30 in. links.
1 set size Mannington pattern elevators
1 set „ „ „ „
1 set „ „ „ „
1 set „ „ „ „
1 set „ „ „ „

NOTE:—These sizes in accordance with casing used.

1 spider with bushings and slips to catch all sizes of casings to be used, also slips for 4 in. and 6 in. drill pipe.
2 100 ton hydraulic jacks, 18 in. raise.
1 Guiberson mills (or similar) tong handle only.
1 jaw for 4 in. drill pipe.
1 „ „ 4 in. tool joint.
1 „ „ 6 in. drill pipe.
1 „ „ 6 in. tool joint.
1 jaw for each size casing used.

1 No. 16 Vulcan chain tongs with extra chain.
2 No. 15 „ „ „ „ one extra chain.
2 No. 13½ „ „ „ „ „ „ „
4 18 in. Stillson wrenches.
2 24 in. „
1 36 in. „
2 15 in. combination wrenches.
2 18 in. monkey wrenches.

Miscellaneous and Blacksmith's Tools.

1 One kilowatt electric lighting outfit complete with all necessary wiring and lamps for one drilling outfit.
1 No. 4 steam blower.
1 300 lbs. oil country anvil.
2 14 lbs. cross Pein sledges and six extra handles.
2 8 lbs. ball Pein hammers and handles.
2 pairs straight lip blacksmith tongs.
1 cold cut chisel.
1 hot „ „
1 square tool dressers forge.
1 portable blacksmith forge.
1 iron tool box.
1 10 in. lock auto-snatch Black Hartz steel.
1 10 in. triple Hartz steel pulley block.
1 10 in. double „ „ „ „
12 5 in. New Style derrick pulleys.
1 combination vise (¼ in. to 4 in. pipe).
1 pipe cutter (⅛ in. to 1 in.).
1 „ „ (1 in. to 2 in.).
12 extra wheels for pipe cutter.
1 stock and dies complete, ¼ in. to ¾ in.
1 „ „ „ „ 1 in. to 2 in.
2 Texas improved oil burners.
12 $\frac{5}{16}$ in. wire rope clips.
12 ⅜ in. „ „ „
12 1 in. „ „ „
1 screw plate.
2 crowbars.
2 socket peavies.
6 long handled round pointed shovels.
2 6 lb. picks with six extra handles.
1 two foot steel square.
3 each solid centre derrick augers (1 in., 1¼ in., & 1½ in.).

2 hand saws.
1 adjustable hack saw frame.
144 12 in. hack saw blades.
1 12 in. common draw knife.
1 plumb and level.
6 oilers.
150 lbs. Babbitt metal.
1 6 in. long handle melting inside pour ladle.
24 assorted files.
3 hatchets with handles.
2 single bit axes with handles.
2 1 in. Jarecki jets.
2 adze eye nail hammers.
1 bale waste.
1 3 in. flue cleaner.
6 blizzard lanterns and spare globes.
25 lbs. each square flax packing, $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in. and $1\frac{1}{4}$ in.
50 lbs. loose hemp packing.
25 lbs. each red sheet packing, $\frac{1}{16}$ in. and $\frac{1}{8}$ in.
25 lbs. each hydraulic packing, $\frac{3}{8}$ in. and $\frac{1}{2}$ in.
1 5 lb. can flake graphite.
25 lbs. Arctic cup grease.
50 lbs. tallow.

Fittings (Boiler and Engine).

2 grooved wheels.
2 150 ft. wire telegraph cords.
6 2 in. brass washer iron cocks.
12 1 in. brass globe valves.
6 each brass globe valves, $\frac{1}{4}$ in. and $\frac{3}{4}$ in.
24 2 in. malleable iron tees.
48 1 in. „ „ „
24 $\frac{3}{4}$ in. „ „ „
12 $\frac{1}{2}$ in. „ „ „
24 2 in. „ „ ells.
48 1 in. „ „ „
24 $\frac{3}{4}$ in. „ „ „
12 $\frac{1}{2}$ in. „ „ „
24 2 in. cast iron plugs.
48 1 in. „ „ „
24 $\frac{3}{4}$ in. „ „ „
12 $\frac{1}{2}$ in. „ „ „

24	2 in. × 1 in. bushings.
24	1 in. × ½ in. „
12	2 in. oil country flange unions.
6	each unions, 1 in., 2 in., ¾ in., & ½ in.
48	2 in. assorted nipples, 12-3 in., 12-4 in., 12-5 in., 12-6 in.
48	1 in. „ „ 12-4 in., 12-6 in., 12-8 in., 12-10 in.
48	¾ in. „ „ 12-4 in., 12-6 in., 12-8 in., 12-10 in.
24	½ in. „ „ 6-4 in., 6-6 in., 6-8 in., 6-10 in.
6	1 in. standard brass horizontal check valves.
2	1 in. Penberthy injectors.
1	2 quart lubricator.
500	ft. ½ in. standard pipe.
1000	ft. ¾ in. „ „
1000	ft. 1 in. „ „
500	ft. 2 in. gas line pipe.

Control casing heads, oil savers and suitable connections should be considered, and, possibly, specified with first equipment. Every specification of casing should include suitable shoes.

The President proposed a vote of thanks to Mr. Maurice Ockenden and Mr. Ashley Carter, and then read extracts from the communications received from Mr. Calder and Mr. Arnett.

DISCUSSION.

Mr. H. Barringer thought the Institution should be greatly congratulated on having received another paper from Messrs. Ockenden and Ashley Carter. He very well remembered the last paper, and thought the present one fully maintained the reputation of the authors. They not only gave information of the latest practice but described the means by which the different operations were carried out, and at the end of the paper they gave very full details of all the gear required to carry out those operations, a thing that was seldom obtained in any papers. Therefore they practically led the members by the hand, and it was the members' own fault if they did not go right. With regard to the mud-laden fluid, or what he should prefer to describe as sludge, it was an interesting matter, on which the authors had given so much information that naturally everybody wanted more. He would like to know whether the mud pump was specially designed in any way, with regard to the barrel, piston, packing rings and valves, to deal with the sludge, which in some cases had 33 per cent. of solid matter. One of the illustrations

that evening showed the mud pit, but it was not quite clear how the mixture of sludge was obtained. Were there any means of ascertaining whether a fixed amount of solid matter was always delivered to the pump, and was there any mechanical means of mixing it? It was mentioned that grit should be avoided, and he would like to know whether there was any straining before the mud was delivered to the pump. With regard to boring, what had specially interested him was the power required, and there was nothing said in the paper about the power required to revolve the drills. There was a mention of the breaking strain of the upset screwed joint which had overcome the difficulty of the weakness at this point, and if there were any data showing the usual power required and the factor of safety allowed on the tools it would be interesting to have them; also had a worm drive ever been employed instead of bevel pinion? Mention was also made of the keeping of logs. That was a very important point, although it was only mentioned quite incidentally. He would impress upon all managers and prospective managers of oil wells to be very careful with all logs, and not only logs, but all information they sent to this country. He had no doubt others had suffered as he had through insufficient information. In ordering material certain requisitions were sent home and one important item of information was omitted, and there was the necessity of cabling out again. Even if there was introduced into the logs and requisitions and reports what the engineers on the ground thought was a trivial matter, it would be found to be not always trivial. The smallest item might be of great assistance to those who were in this country and who had to decide what was to be sent out and what was not. Therefore he would impress upon all managers to omit nothing, even though they might think they were giving useless information. It was impossible to say whether it might not be very valuable although people on the ground, knowing all the conditions, might think everyone was fully acquainted with those conditions.

Sir John Cadman congratulated the authors on having read a very instructive paper. The paper, in so far as it referred to plant, did not lend itself to discussion, as it was largely a statement of facts; but there were questions incidentally touched upon which were worthy of discussion. He felt that we were passing through a phase in connection with petroleum geology which was of considerable importance. Geologists of to-day were studying the fragments obtained from percussion and rotary bore-holes in a much more careful and scientific manner than hitherto, indeed the rock structures were being built up by such fragmentary

evidence. It was true that it was difficult to state exactly what the material was from that fragmentary evidence, but, when coupled with the detail which could be obtained in the rate of progress of drills, it was certainly possible—and would be still more possible with better knowledge on the subject—to construct logs that would be of use and not the useless records as they are in many cases to-day. He was sure that many members had had experience of what he himself had frequently experienced when examining well logs. He remembered having to look through some logs and to cross-examine a driller on what he had recorded in the log. Terms such as "Gumbo," "shaley sand" and "granite" appeared and this in Tertiary formation! When the driller was asked whether he really passed through granite, his expression was that it was "as hard as hell, and if that was not granite he did not know what was."

In connection with rotary as compared with percussive drilling, they are both necessary. The authors had rightly referred to the danger of using hydraulic rotary methods in prospective drillings. It was well known that in actually searching for oils a hole that was filled with water did not give the best conditions for detecting the presence of oil in a porous bed. For that purpose a dry hole was essential. Both methods were indispensable and had their right places in drilling. With regard to the mud flush system, it was a development that had been for some time introduced with considerable success, and was being employed with cement in place of mud on occasions. A well was put down in this country at Haswell in which a cement flush system was adopted, and in this case the cement was inserted during drilling and not through the boring stem but in the reverse direction. The Haswell bore-hole was put down some 3,000 ft. without any casing, and it is quite conceivable that such a method will find its way into oil practice and relieve a great deal of the difficulties which had been found hitherto in regard to casing. It was most important to have very adequate methods of regulating the feed and speed in a rotary system, and he thought manufacturers of plant had not given sufficient attention to this subject. It was true that many drillers simply let the drill rip without any knowledge of the value of regulating the feed in accordance with the hardness of the rock through which they were passing. That was a matter which would adjust itself when more experience had been obtained in drilling, and when more qualified drillers were employed. It should not be forgotten that the industry was one which was comparatively young—only 40 or 50 years old—and it took time

for such processes properly to evolve. He wished to pay his tribute to the authors for the very excellent paper.

Dr. W. R. Ormandy said the one aspect of the paper which had appealed most to him was naturally not the mechanical side but to see how far pure science was applicable, and it was sometimes of interest to note that comparatively abstruse matters had a direct bearing on a very practical subject. Mr. Barringer had raised the question of the nature of the mud flush and the method of handling it, and the means of finding out the thickness or gravity of the flush. In connection with work which he had had to do, he had to deal with large quantities of clay substance which had to be pumped, and the question of finding pumps to handle that liquid was becoming a very serious problem. If ordinary clay was employed and was mixed into a paste or thin slime with water, it had to be allowed to get very thin indeed before the grit or sand would settle out of it, and if any attempt was made to pump it in that condition there was great wear on and rapid deterioration of a positive piston pump. If a high pressure had to be employed, there were few types of pumps available, but if the pressure was not great there was a considerable number which could be employed. He ventured to submit that a better system was to get rid of the grit, and that could be done by taking advantage of the fact that a clay suspension was a colloid suspension. An ordinary sample of clay mixed with water, say 1 lb. of china clay mixed with 1 lb. of water, would form a paste of the nature of Devonshire clotted cream, a thing that could be only extruded by a pump. If to such a suspension or mixture of clay and water was added a trace per cent. of the weight of the clay of a suitable electrolyte, a wonderful change was brought about. The thick creamy liquid was converted into something resembling skim milk, and it was then possible to introduce two to three times the weight of clay into the same amount of water and yet have a liquid which was much thinner to pump and nicer to handle than the original clay. By mixing the clay with water into a comparatively thick cream and then adding the electrolyte and allowing the liquor to settle for a quarter of an hour, it was possible to obtain a liquid which was freer from grit and sand than could be obtained probably by a week's settling in the original state. The principle of adding an alkali to a clay liquid with the object of thinning it down was introduced in the first place into the pottery industry by Weber of Germany, to enable very thick suspensions of clay to be cast into porous moulds made of plaster of Paris, with the object of getting an article which would rapidly dry and could be burned, but

Weber added large amounts of alkali, 2 or 3 per cent., and it was the discovery of Count Schwerin that minute traces of alkali were sufficient to convert the clay from the jel or jelly form into the sol or solution form. In connection with boring, it was a very simple thing to put the clay material which it was desired to convert into mud into a tank, stir it up or agitate it by some means, and add a trace of alkali and allow the sand to settle; and in that way a fluid could be obtained having three to four times the amount of solid per cubic ft. than could be placed in the water if the alkali was not present. It was an advantage that the fluid clay material, consisting of only clay substances and with no grit in it, passed down the bore-hole and, as it entered into the interstices, the particles, being 1/100 to 1/1,000 part of the mass of the original clay particles, met with the salts which were present in the waters below and coagulated *in situ*. As the thin liquid penetrated into the pores of the outlying portion of the bore-hole, it coagulated and made a waterproof lining. It would be seen that even work on such subjects as refractories could have a direct bearing on mining which seemed very far removed.

Mr. Templeton did not think the authors had made quite enough of one point, and that was the chief disadvantage which the pure rotary system admittedly possessed, namely the liability to pass paying streaks of oil strata. He did not think the advantages which were generally admitted, namely, less cost of casing and increased speed in getting through the softer strata, came very much into the picture except when there was a dry hole. So long as oil was found, the increased cost of casing did not come very much into the account. One instance of passing through a paying oil stratum might easily more than balance the savings of many wells drilled on the same oilfield by the rotary. Therefore in his opinion the pure rotary should be completely banned for use in areas except where used for simply getting down to a definite depth above the danger zone. It had been said that the best way to use the attractive and valuable features of the rotary was to use it in combination, but there again, unless there were some adequate governing power to regulate the places at which the rotary would be used, there would be the same liability to pass the paying streak, and therefore it should be only used under very strict administrative control.

Dr. Henderson said the advantages and disadvantages of the rotary as compared with the percussion type in prospecting work or making geological sections of any unknown area were well known and had been thoroughly thrashed out, but there seemed

to be no opinion one way or the other as to the positive disadvantages of the rotary in some fields, and thus whilst in some fields it undoubtedly should be barred for the purpose of prospecting, in others it seemed as if it were almost impossible to get down to the requisite depth by means of the percussive system, except after years of work, and the rotary therefore answered the purpose in some cases without giving perfect results. Allusion had been made to the desirability of manufacturing an adequate supply of oil-well material in this country, and he thought everyone hoped that that would come to pass very quickly. The American practice of having practical oilfield men on their staff, men who understood every stage of the subject and were able to advise clients in regard to any new materials or tools which were introduced, was a very desirable thing in starting any enterprise of this kind in this country. The paper was purely a record of facts of a very valuable nature, for which every member must feel indebted to the authors.

Captain Mangin was inclined to agree that there was very little to criticise in the paper, but there were one or two points of interest which might be mentioned. He thought the authors had made a mistake in laying down the figure for the consistency of the mud flush at from 20 to 33 per cent., and he thought they would modify their views and agree with him that a variation of even 2 per cent. under certain circumstances would make all the difference between success and partial success. It might increase the footage of a run anything up to 15 or 20 ft. He was speaking more particularly on hydraulic percussion, but much the same remarks applied to the other. There were many instances where it was necessary from force of circumstances to use a much thicker mud flush than was convenient, and he would be very interested if the authors would say what difficulties had arisen through that. There were certain sands, for instance, in which it was necessary to use an extremely thick mud flush to get through at all; they would not stand up 6 in. to the head of the bit. The great trouble was twofold. If there was a casing there was a tendency to circulate behind that casing, with the results indicated in the paper; if there was no casing any deposit of mud in the upper part of the bore would give an extraordinary amount of trouble. When the men tried to pull the tools they would not pull. Personally he had spent the best part of a day and sometimes the best part of a night as well trying to extract tools from a bore where he had had to use a mud flush which was thicker than it ought to have been and which had deposited itself on the upper part of the bore and reduced the diameter some inches below that of the bit. Another point,

which was perhaps not quite relevant but none the less interesting, was the question of portable plant. The authors had shown a photograph of portable plant—the Columbia driller with a rotary attachment. He was prepared to state that there was no portable plant on the market and he thought he had tried them all. If it was portable it would not drill; if it would drill it was not portable. He had tried eight or nine different types within the last 3½ years, and if anybody could show him a portable drill which would make a hole under all conditions he would take his hat off to him, because he was perfectly certain the thing did not exist. That was a thing to which English manufacturers might turn their attention and do a great deal of good. A portable rig must be designed and not thrown together. He would almost extend his remarks to the average type of driller; it was chucked together. What had to be done—he believed the Institution was the only body that could do it—was first of all to design a plant suitable for all possible conditions, and then—which was more important and more difficult—train men to run the plant and train them on engineering lines. At the present moment there was not, in his opinion, a trained driller available throughout the world, except a few men who had been trained by the people they were working for. The ordinary driller who had a fabulous rate of pay, was colossally ignorant even about his own job; he had not the education to study and had not the education to put the results he obtained on paper, and all the practical information which might be got from deep borings all over the world was largely lost on that account. The man who went round visiting could collect a certain amount of information from what the drillers told him, but the man who could give useful information was the driller, and ninety-nine times out of a hundred he was not sufficiently educated to do so. He believed the Institution should not only get plant designed, which was an engineering job from top to bottom, but train men to run it so as to produce a first-class driller from this country. There was no reason why it should not be done, and he was certain the next two or three years would see it attempted at any rate. He would like to make a case for the hydraulic percussion system as against the rotary. He believed he was right in saying that very good results could be obtained, and it had other advantages. In the first place the original plant could be to a certain extent a designed machine. The average type of plant could not by any stretch of the imagination be said to be designed. Another small point was the question of tools. The Americans had to a certain extent standardised tool joints, that was to say, they were standardised for any particular

string of tools. If a string of tools was ordered and further application was made to the same factory, it was impossible to get a set of jars which would fit that string of tools; one would be obtained that would fit by $\frac{1}{8}$ in. or $\frac{1}{4}$ in., and it might be necessary to fit hard steel washers under the joints or put the thing in a lathe and cut the threads over again. There was no standardisation worthy of the name. Tools obtained from two different makers were useless and tools from the same makers became useless, because they had been made for some particular user who had his joints made a little thick or a little thin. Until a factory was started in this country which would turn out standard tools with standard tool joints, there would not be very much done in the way of scientific drilling.

Mr. M. A. Ockenden, in replying to the discussion, said Mr. Calder had touched on a subject which had been referred to by other speakers that evening. He himself believed that the British manufacturers were at a great disadvantage at the present time in not being able to have daily and almost hourly contact with the actual process of drilling, the drillers themselves and the whole organisation. A field had not yet been sufficiently developed large enough to justify manufacturers building up plants which they could only do if they had men who were constantly visiting fields. Mr. Arnett had referred to the first well not being put down by Col. Lucas. The paper stated that the first gusher brought in by a rotary was brought in by Col. Lucas, and the authors did not know that Mr. Hamill was the driller. There had been several claimants to the first use of mud flush, and for that reason the authors had thought it better not to go into detail, because they found a good deal of contradictory matter in even the American Geological Survey Reports, which gave several dates. With reference to Mr. Barringer's remarks on pumps, the sludge was, as far as could be learned, almost like a muddy stream. The mud fluid pumped into the well came away from the bore-hole in the form of sludge, and as it flowed along the ditch, which was made as long as possible according to the formation to be drilled in, heavy matter was deposited in the same manner as the sand is deposited in a small stream at the side of the road, and the turbid water flowed back to the sump or pump chamber practically free from the heavy detritus and sedimentary matter. The pumps were constructed to stand a pressure of 1,000 lbs. per sq. inch, which was now the usual working pressure. The glands were packed with the ordinary hydraulic packing and the cylinders were made with liners which could be easily taken out and renewed. The chief features of the pumps were their strength. Drillers worked differently

and men who had been operating with cable tools and suddenly took up hydraulic rotary had remarked that it seemed as if the bottom of the hole had come out, because they were so accustomed to feel the weight of the bit on the bottom of the hole. The feed was more sensitive and more rapid than with the percussion bit. Apparently it took some time to educate men to the use of the hydraulic on that account. Nomenclature was an important matter which he hoped the Institution would take up, as it would help the manufacturers and everyone connected with the industry, moreover some standardisation that could be adopted in various languages. Sir John Cadman had referred to cement and mud flush. In a recent technical paper issued by the Bureau of Mines in America, it was stated that they were now using mud in place of cement in California and in the Northern Texas field. Cementing was a very serious problem, and if it could be effectively overcome with mud, as they apparently were doing in America, with gas pressures of 700/800 lbs., and upwards per sq. inch, 2,000 ft. deep, it seemed unnecessary to introduce cement. Dr. Ormandy's very valuable and interesting remarks were of great importance. The fluid was practically a muddy water which would flow through the pump when it came to the pump chamber, but as it left the bore-hole it was certainly a sludge formed by the detritus caused by the bit. Mr. Templeton had said the paper had not dealt with the disadvantages of the rotary in passing through paying sands. In one of the recent bulletins of the United States Government it was said that 10 ft. was considered the maximum, that was to say, paying sands would have to be 10 ft. in thickness before they would be discovered if the pressure of gas or oil was very slight. With regard to the percentage, there seemed to be a certain amount of experimenting still going on, and probably it would continue with regard to the proportion of clay which should be used. Mr. Knapp, Senr., claimed 33 per cent. of extra weight of clay, but did not describe the clay he used. A few years later the Government issued 20 per cent., and those figures had been introduced into the paper. The authors had no suggestions to make with regard to that, because neither of them had had experience in using it. The paper was supposed to be a paper on plant, but there had been a good deal of discussion on the mud-laden fluid. With regard to portable machines, that was simply an expression. It was quite true that there was no complete portable machine, and certainly there was no complete core drill portable machine or rotary portable machine. It would be more correct to say " portable rigs " and not " portable machines." It would be a difficult matter to educate British drillers, because this

country was at a great disadvantage in not having contact with large fields. It was true that many drillers were just doing routine work and were not educated as they should be. If engineers would only take an interest in the matter, he thought the present conditions would very rapidly change. The authors would be pleased to see the introduction of British drillers, as it would help everyone concerned. They had put on the board for those who might be interested in it an average for the present pipe used in the fields, showing the amount of drill pipe and casing used in Texas, California, Oklahoma, Pennsylvania and Mexico, and from that table it would be seen whether the installations were cable tool, rotary tool, or combination. So much had been said about the rotary in California that it was very curious to find there was very little straight rotary there; it was practically all combination; whereas in Texas or part of Texas it was nearly all rotary. In conclusion, the authors wished to thank the members for the appreciation they had given to the paper.

The meeting then adjourned.

Mr. W. Calder in a written communication said it was regrettable, but nevertheless true, that a large section of the public interested in oil have very vague ideas as to how natural oil is obtained from the ground, in some cases this ignorance is even manifest in those occupying responsible executive positions in London oil circles. But when drilling tools are referred to, how many of the latter can explain the uses of the various tools, or even discriminate on the respective merits of the various drilling systems —and yet without tools we would have no wells!

To date the manufacture of oil well tools and plant has been essentially an American industry, British manufacturing mechanical engineers, despite the high position they hold for the production of general mechanical machinery and plant for all classes of industry, have not up to the present made any great headway in the manufacture of oil well tools and plant. During the recent war, water in abundance was required at all points where troops were in any number, the local supplies in most cases proved insufficient and it was necessary to drill shallow water wells, even the plant for this purpose had to be got from the U.S.A., likewise the drillers or workmen. The reference to water well drilling may appear a digression, but the cable tools and machines used for water wells are identical and similar to those used for shallow oil well drilling, at the moment there are only two manufacturers of oil well drilling plant in this country. Recently in one of our London papers it was stated that British capital to-day controlled between 60 and 70 per cent. of the

world's oilfields, if this is so surely our manufacturers can come forward and supply a little more of the plant and tools than they have done up to the present. In the United States, owing to the shortage of home oil supplies, the Government has taken special steps to enquire into the oil shortage and suggest improvements, the result has been that a vast amount of extremely useful information has been collected and circulated amongst oil producers and manufacturers in that country. Cannot the Institution approach the big oil groups and the Government for financial assistance so that a permanent Committee of our best oil engineers could be adequately remunerated for their time in preparing and standardising some of the following :—

Drilling Systems,	Well Casing,	Drilling Tools,
Specifications,	Derricks,	Cementing & Water
Preservation of Gas,	Cost Keeping,	Shut off,

and the hundred and one other subjects which have to be thrashed out by the oilfield engineer and manager some time or another on all oilfields.

The rotary system of well drilling, although successfully used in the 'eighties for water well drilling through sand and broken strata, only came to the fore for oil well drilling when the Spindle Top Oilfield, Texas, was developed, from there its use was extended to Louisiana, California and other parts of the world. In all of the fields where it was adopted records were made in drilling through loose strata and in which the percussive systems had previously made poor progress. The fast drilling recorded naturally attracted attention, particularly amongst those who were in oil as a means to get rich quick. On the other hand all operators and engineers who had been used to the percussive system looked on the rotary with disfavour, in particular for prospecting purposes, claiming that the standing head of water and mud in the well would tend to drive away any signs of oil or gas from the vicinity of the well-indications which might lead to paying oil being developed. That there was reason for this scepticism was proved later when it was found that the drillers had passed the oil horizon by 80 ft. in the original Lucas well on Spindle Top, in all probability the oil would have been shut off had not the work been stopped for the men to have a meal, and it was during the stoppage that the oil showed at the surface. The famous Dos Bocas well in Mexico was drilled with the rotary and likewise broke loose while the drilling crew were at breakfast. Many other cases could be cited where promising surface indications of oil on being tested with the rotary have shown no traces of oil or gas in deep tests.

Devotees of the rotary always persist in stating that this system is much cheaper than any of the percussive systems of well drilling, and invariably bring forward their well drilling speed records, in many cases they certainly can show that less casing was used also that the *drilling day* speeds were greater, but when the percussive and rotary are compared it is usually found that the total well days differ very little in both; as regards the reduced amount of casing the extra cost of this with the percussive system is offset by reductions in costs on other items such as labour, fuel and the heavy cost of the rotary drilling stem, finally with the percussive system the work is more satisfactory and permanent should heavy gas and oil pressure be encountered.

Mr. H. May, in a written communication, stated he wished to record his appreciation of the paper so ably prepared by the authors and would like to contribute a few remarks. The question of logs has frequently been discussed and until these are prepared by competent and qualified men little or no satisfaction can be expected. The majority of geological (so-called) logs only lead to confusion and nullify every effort of experienced geologists to unravel the mysteries presented under the heading of geological data. Samples taken every few feet should be carefully preserved for investigation by a trained geologist who should be deputed to make out that part of the log reserved for that purpose after discussing the day's work with the driller. Satisfactory samples can, however, rarely be obtained from a well drilled by the rotary.

Mention was made by one of the speakers to "Indents" received from the "Field." In many instances these are so incomplete that it is only with difficulty, and sometimes impossible, for even experienced men, to prepare specifications with the certain knowledge that the correct plant or article is being supplied. Details are not necessary, but salient points should be stated whenever possible.

A paper recording the history of rotary drilling should, he thought, make mention of the "Calyx" core-drill which was first introduced into this country from Australia about 1896. Some four years later it was employed for drilling oil wells in Baku but without appreciable success. Its failure was due primarily to an inherent defect of all fixed steel rotary cutters in that whilst penetrating hard sandstone the rock acts as a grindstone, resulting in a penetration of the rock about equal to the wear on the cutter. In some rocks he had known the toothed cutter to wear down 1 in. while the rock was penetrated only about $\frac{1}{8}$ in. Another defect of the Calyx drill is the liability to seizure in sand in the event of

stoppage of the flow of liquid, the clearance between the "Core barrel" with "Calyx tube" and the sides of the hole being not more than about $\frac{1}{4}$ in. There is also the difficulty of breaking off large diameter hard rock cores. It must be realised, however, that in suitable strata this drill gives very satisfactory results. He would be interested to know if a satisfactory rotary underreamer exists, he has designed and used such tools for special purposes but was never satisfied. An interesting core drill used in America in certain coal districts is a tool somewhat similar to the Calyx but having a double core barrel, the inner tube remains stationary whilst the outer tube only rotates, the flush passing between the two tubes. By this means the coal or other friable core is not destroyed by friction and is protected from erosion by flowing water.

The question of standardisation is very important. Claims are made by American manufacturers that all tubes and tools of a given size are interchangeable, but unfortunately this is not always so, as he knew from bitter experience. So far as rotary tools are concerned no such claim is made, consequently once a certain make of plant is installed, the natural desire of operators to standardise plant on the field compels the placing of subsequent orders with the same manufacturer. From the point of view of the operator this is not desirable, and he thought also that it is not advantageous to the manufacturer.

The question of manufacturing drilling plant in England on a large scale, is, he believed, under consideration; now is the time to settle standards. He thought therefore that this very important matter should be widely discussed, and suggested that the big Companies also endeavour to come to an agreement so that British standards may be acceptable to all British Companies.

Under heading "Machinery" in the specification attached to this paper the boiler power appeared to be quite inadequate. Reference to horse-power in connection with boilers is meaningless, duty should be referred to in terms of evaporation from and at 212° F. with a given fuel. The 45 h.p. boiler in question with liquid fuel is probably large enough to generate sufficient steam to develop 70 b.h.p. in the engine, but with wood fuel it is doubtful, in fact the low rating of American oilfield boilers is probably based on wood fuel. It would appear that about twice the steam provided in the specification is required, the two large pumps, of a type known as "steam eaters," being unprovided for. This is not intended as a criticism of the design of pump which is admirable for the purpose, but to point out the inadequacy of the steam plant

and particularly to lay stress upon the desirability of abolishing out-of-date and incorrect references to h.p. of boilers.

To which the **Authors** rejoin that they have no knowledge of what results have been obtained with the milling type of under-reamers. In reference to the boiler and engine, the Authors thank Mr. May for drawing their attention to the error which has been rectified in the specification.

Mr. W. T. Arnett in a written communication stated: Drillers should be instructed that they must not allow the attainment of depth to overcome the prime necessity of "keeping" the hole true and speed must be subservient to this object. To achieve this the well must at all times be kept full of mud-laden fluid of a consistency as thick as the pumps will handle freely. In other words the mud should be practically as thick (or heavy) as the formation taken from the bore-hole. This prevents caving of the walls of the bore-hole and enables proper samples to be secured. Whilst these salient points are observed by experienced rotary men they are seldom given the prominence they require by cable-tool drillers when using rotary drill.

He agreed that there is much to be learnt in rotary drilling, and the selection of rotary drillers should always be the first care.

This term is not an appropriate one and is not generally understood, and suggests that the mud permeates the walls of the bore-hole which is not true, this only happening in the case of clear water, i.e. a well he drilled in 1914 in Russia to a depth of 220 ft. at which point 12 in. casing was landed after which water was pumped into the well for five days without any return flow. He then closed down the plant and mixed ten tons of mud (slush) a quantity of which was pumped into the bore and which enabled him to continue drilling to a depth of 3,008 ft. without using any further casing. This is only an isolated instance of the value of mud "slush." This latter is the more appropriate and generally understood term.

In Brea Canon, California (Fullerton district) in 1912, the Delaware Union Oil Co. had 10 in. casing set in one of their wells at 2,700 ft. on heavy sandstone. The formation was readily cut by the cable tools, but before the tools could be drawn and the sand pump lowered the sand had settled down and could not be picked up by the pump. The rate of progress was only a few inches a day when it was decided to install a rotary plant. After this plant was installed he used a 9⅞ in. Sharpe & Hughes rock drill-bit and in the first nine hours had drilled 36 ft. So that with the present modern rotary rig he had no hesitation in saying that there is no formation too hard for it to readily penetrate.

The "experienced" California engineer's experience was evidently only confined to cable work. Had he had a proper training of rotary work he would not have made the strictures related in the report, as the vibration of the drill stem immediately indicates to an experienced driller the change of formations. As regards water sands these are easily detected by the thin milky appearance of the water floating upon the mud fluid which cannot be misinterpreted by proper rotary drillers.

Gas and oil is first detected by the oleaginous odour which accompanies the return fluid, the latter being of a higher temperature than at the surface, and is specially noticeable at night when the exuding vapour remains around the bore-hole. On this happening the driller immediately makes a record on his log and suspends drilling operations until samples have been secured.

By this time gas and oil can be observed floating upon the mud-fluid.

In regard to the question of keeping a correct log, the authors omitted to mention the cavings due to cable tools which would prohibit getting a good clean sample, but it is not clear from their observations that this does not happen when using a rotary.

The data having regard to the first oil well drilled by the rotary is not correct. The well referred to as put down by Colonel Lucas was drilled by Hamill, who had been successfully operating a rotary in Corsicana, Texas, for three years previously. The depth of the "Lucas" well was 1,125 ft. and produced about 40,000 barrels *per diem*.

In conclusion, he would like to observe that mud-laden fluid was first utilised by Mr. T. J. Baldwin as far back as the year 1898 in a 4,000 ft. well drilled near Galveston (Texas) when seeking a fresh water supply.

He might also mention that to ensure a "straight" hole it is very essential that the rotary be run at the highest possible effective speed, and slowly-fed pumps should be run according to the formation encountered.

Moreover, it cannot be too strongly impressed upon oil-well engineers the advisability of adopting a combination rig with which it is almost impossible to lose a bore-hole, as whatever obstruction is encountered by one plant can be overcome by the other, that is to say that any tools lost can be either fished out or side-tracked.

Mr. W. H. Booth, in a written communication, stated: There is no royal method of drilling a well and no special system can be said to be the best for any particular job, especially in Great Britain where conditions are more variable than abroad owing to

the higher inclination of strata. To persist in the use of a rotary system right through a boring is to persist in loss in many cases. Every system has its advantages and the reverse, and with a rotary gear cores are obtainable to the great good of geological knowledge. But it is not always possible to get a core. Often a mere fraction of the depth drilled ever appears as a core at the surface. Thus in a boring I have at present in hand, on which rotary systems have been used throughout, the first 70 ft. showed only a few lumps of soft chalk and a few flints. Thence to 236 ft. the only output was a sharp debris of comminuted flints and a wash of whiting. Thence to 300 ft. a fairly continuous core was obtained to the base of the chalk rock. In the middle chalk one-seventh of a two days' drilling came up as core and a maximum of 90 per cent. was one day secured. In the lower chalk the full drilled length was brought up as core and raised, the average recovery in a drilled length of 550 ft. of middle and lower chalk to nearly 80 per cent. The upper gault cores could be lifted, but the lower gault was too soft and slippery to lift by the gravelling system, and the contractors cut them away, thus destroying the palæontological advantage of rotary work at the very point where it would have been most valuable. But the rotary gear enabled me to bore from 300 to 900 ft. without casing and one-fourth of this unlined hole was in the gault clay. Either because of its weakness or because of the great pressure on the gault a bore-hole soon becomes obstructed by so-called falling in. There are reasons to think this is more an intrusive than a decaying effect.

In my opinion improvements are needed in the way of picking up cores. Gravelling, so much practised is uncertain and productive of great delay, loss of time and damage to tools as well as confusion of core lengths when they fall pell mell out of the core tube.

Rotary gears driven by chain gears I regard as bad practice, for in case of serious obstruction there is risk of rod breakage and other troubles, notably such excessive screwing up of rod joints that they cannot be parted. The best rotary drive is by canvas belt with the canvas against the pulley faces. The belt needs to be sufficient for the work but not excessive. It can then slip and safeguard the drill. It should run on a wide pulley and the flywheel effect between drill and belt should be a minimum so as to diminish shock and sudden stress due to obstruction to rotation of the drill. Shot for rotary drilling ceases to be useful at an early point in the case of soft or smooth grit free rocks. The crown cutter should then replace it and with a crown cutter worked either on the percussion system or on the rotary system cores every bit as good as shot drilled or diamond drilled cores may be secured.

As regards mud flush work, the ideal "mud" would be necessary for we may sweep away nine-tenths of the vague claims for mud and explain its action as due to two things only. First being mud the solvent property of the water in it has been more or less reduced, and just as saturated salt solutions will no longer wash away more salt, so will mud leave the soluble earths free from further rapid attack.

Secondly, mud, being of high specific gravity, is more effective in keeping the walls of a bore-hole from intruding into the drilled space. Mercury is unfortunately dear or it could be employed to prevent bores "falling in." It would float up to the surface all debris and save the use of the sand pump or core lifters. But it is very mobile and would soon be lost, especially where fissures had a drawn slope from the bore-hole. Unfortunately also it would be very difficult to use shot with it, for, except with very special precautions the shot could not be got down to the drill nor if put down would they remain there. But, impracticable as the metal is, its weight and great mobility are qualities we may well seek in other directions as far as this is possible, and the colloid muds referred to by Dr. Ormandy at the meeting should afford great help to future drillers. But would the soda charged water more actively attack the clay walls of a hole?

I can say with truth that in all my experience I have never yet had a set of reports from a boring which could be described as really good. The foreman who makes the report omits the apparently trivial facts which in a few days or weeks later would be so valuable. A good log should be in diary form and contain each day every particular as to depth, casings, etc., as well as the day's progress and happenings, and the copy should be in the consultants or residents' hands next morning, and it would be good to accompany the log with a drawing and the usual sample boxes.

The authors acknowledge Mr. Booth's comments in reference to core drilling plant, but as cores cannot be produced at present without water flush, it is most undesirable to use such methods in the oilfields. With reference to the chain drive, it is necessary that there should be a positive drive from the engine or power to the rotating table. If a belt were used (as is the case with percussion methods), the slipping or breaking would necessitate immediate "freezing" of the drill pipe by sedimentation of the mud fluid in, perhaps, a well of several thousand feet in depth. The duplex asbestos lagged brakes are a great feature of the modern rotary hoist, giving complete control; moreover, one of the secrets of the success of the "mud flush" rotary operation is slow feed.

COMMUNICATED.

The Classification of Undeveloped Oil Land for Purposes of Valuation.

By CARL H. BEAL.

In valuing oil land during the last few years, the author has found it necessary to adopt a standard for classifying the lands to be valued. Some standard of classification is necessary, not only in valuing oil properties, but also for use in publications dealing with the oil resources of individual fields. If a publication or report—public or private—states that there is a certain number of acres of proved oil land in the United States, the adjective "proved" should be so standardised that it will immediately have the same meaning to all.

This need of some uniform classification, especially in the valuation of oil properties, seemed so apparent that the author prepared and sent a circular letter to a number of geologists and petroleum engineers, who probably would be interested, requesting their views on tentative definitions. Many suggestions were received and the definitions herein proposed may be said to be a consensus of opinion rather than the opinion of one person. The author claims no credit except of having combined the ideas of others into usable definitions.

Although ideas and suggestions were gained from numerous conversations with other members of the profession, the following have contributed principally to this paper: I. C. White, state geologist of West Virginia; J. C. Branner, president emeritus, Stanford University; J. O. Lewis, chief petroleum technologist, U.S. Bureau of Mines; R. E. Collom, petroleum technologist, U.S. Bureau of Mines; Roderic Crandall, Chester W. Washburne, A. Beeby Thompson, Roswell Johnson, M. J. Munn, Arthur Eaton, J. H. Gardner, Dorsey Hager and F. G. Clapp, consulting geologists and petroleum engineers; M. L. Fuller, of The Sun Company; C. R. Eckes, of The Texas Company; E. D. Nolan, of The General Petroleum Corporation; R. C. Conkling, of The Roxana Petroleum Company; G. C. Gester, of The Standard Oil Company of California; and M. E. Lombardi, of the Fuel Oil Department, Southern Pacific Company.

In any classification of undeveloped oil land, the definitions adopted should be comprehensive but simple and, if possible, as easily applicable to the sharply-folded fields in California as to those occurring in the relatively little-disturbed oil-bearing areas of Oklahoma, Kansas and Texas. The classification must be based

on definitely ascertainable factors, and the definitions adopted must be such that any engineer will experience little difficulty in applying them to undeveloped land in or near any oilfield or in an area where the existence of oil is not known.

The scientific classification of lands involves a broad knowledge of the *occurrence* of oil and gas with relation to geologic structure, the stratigraphy of the beds, texture of the sand, the effect of possible lenticularity of sands on accumulations, modes of accumulation, and the importance to attach to the different factors causing oil accumulation and occurrence. Although classifications made by various persons may differ widely because of the divergence in conceptions of the causes of and factors controlling accumulations, this variation should become less and less as the principles of oil accumulation and occurrence become better known. It has been demonstrated that the classification of lands made in an area where no wells have been drilled, may be radically changed by the additional information disclosed by drilling one well. For example, some anticlines in the mid-continent field, prior to development, may be classed as possible or probable oil land, whereas they are found to be worthless for oil when drilled.

The most useful classification is one based on the oil possibilities of the land. The oil possibilities of undrilled land must be determined absolutely from surface or underground geologic data, including information on the occurrence of oil in drilled areas, similar geologically, factors controlling oil accumulation, etc., unless the undrilled land is adjacent to development, when, in some cases, favourable geologic conditions will be of secondary importance. Any classification of undrilled land, especially if made for purposes of valuation, should show essentially the prospects of obtaining oil in commercial quantities. It seems to be the consensus of opinion that three or four easily definable classes should be set up, because of the difficulty of segregating oil land into more classes. One correspondent, however, advocates the adoption of no particular classes, preferring to apply to different areas, with different chances of becoming commercially valuable land, the mathematical probability which expresses this chance. This probability he would express as a percentage of commercially productive land. For example, if the chances are 6 to 10 of a tract of land becoming commercially productive, the probability will be 6/10 or the percentage will be 60, the percentage expressing the prospect of commercial production.

The author believes it to be practically impossible, however, to gage the factors determining the prospect of production and to

express this prospect mathematically. It seems far better to define a few general classes, and to apply percentages in particular cases, when it is possible to do so and the appraiser finds such a procedure necessary.

Definitions.

General Considerations.—In this paper we are discussing undeveloped oil land only; that is, that land which has some prospects of producing oil, but that on which no wells have been drilled. No definition is therefore given for worthless land, each class defined possessing some implied value for oil purposes.

Undeveloped land possessing some value for oil purposes, may be rather easily divided into (1) proved, (2) probable, (3) possible, and (4) commercially non-productive land, the first three being in the order of the probability of obtaining oil in commercial quantities. A similar tentative classification was given by the writer * two years ago, but it is hoped that the present definitions will supersede the others.

The term "prospective" has not been applied to any of these classes. Although its convenience and universal use argue strongly for its definition, the broad latitude of its meaning renders it almost impossible to define. Nearly all undeveloped oil land possessing any prospects of producing oil in commercial quantities is referred to loosely as "prospective" oil land, and as the term is so valuable when used in that capacity, no attempt was made to restrict its meaning to a narrower sense. Consequently the term "prospective oil land" is not defined as other than that which possesses prospects of producing oil in commercial quantities, and it will thus include in its scope all such land.

Proved Oil Land.—Proved oil land is that which has been shown, by finished wells supplemented by geologic data, to be such that other wells drilled thereon are practically certain to be commercial producers.

This definition has been modified from that given for the California oilfields, by McLaughlin.† The oil Companies in that state, as a general rule, are paying light taxes on proved oil land in accordance with McLaughlin's definition, and although the tax is small, the fact is mentioned to show that a definition similar to the one here proposed has already been accepted by all operators in one part of the United States.

* Beal, Carl H. The decline and Ultimate Production of Oil Wells with Rates on the Valuation of Oil Properties. *Bull. U.S. Bureau of Mines*, No. 177, p. 82, 1919.

† McLaughlin, R. P. Petroleum Industry of California. *California State Mining Bureau Bull.*, 69, p. 13, 1914.

The modified definition was proposed by the author in a publication of the U.S. Bureau of Mines * and later to the Bureau of Internal Revenue, Treasury Department, in January, 1919, for incorporation by that Bureau in the regulations relating to income tax and was given by the Treasury Department† for the use of the oil operators.

The basis of the definition is the *practical* certainty of obtaining oil in commercial quantities, and land cannot be placed in the proved class if any doubt exists regarding this practical certainty. The practical certainty is based on the data from wells that have already been drilled; geologic data are supplementary or secondary. Information given us by the drill is usually final, although our observations for the determination of proved acreage should be supplemented by such geologic data as are available. Contiguous producing wells are, therefore, a necessary pre-requisite; the author has never found a case where the underground conditions of land not contiguous to producing wells were sufficiently well known to allow its being placed in the proved class under the definition given above.

Possibly some may consider the word "practically" unnecessary, but we cannot be absolutely *certain* of obtaining oil from wells drilled on any undeveloped land until the sands have been tested. In our past experience or practice, however, we have found that undeveloped land with the same prospects as contiguous developed land has yielded oil: "practically" means "not theoretical" or in a "practical way," so that the word becomes useful in modifying the definition, lending the slight element of uncertainty to such land that it deserves.

It should be brought out that the wells must be *commercial* producers, that is, the prospects must be such as to justify commercial exploitation. Quantities sufficient to justify commercial exploitation, as defined by the Treasury Department ‡ "are deemed to exist when the quantity and quality of oil or gas so recovered from the well are such as to afford a reasonable expectation of at least returning the capital invested in such well through the sale of the oil or gas, or both to be derived therefrom."

The number of wells necessary to prove an area will vary with the conditions. With a well-defined structure and well-known sand conditions, three or four wells may prove up a large area, whereas if the sand is irregular and the structure certain or if the

* *Op. Cit.*, p. 82.

† Regulations 45, relating to income tax and war profits and excess profits tax, under the Revenue Act of 1918, 1919.

‡ T. D. 2956 with Regulations 45, approved Dec. 2, 1919.

sand is known to be uniform and the structure of the oil sand uncertain, much of the area would be placed in the probable class till more wells were drilled. Land cannot be proved—that is, fairly certain to support commercial producers—unless the sand is known to be fairly uniform.

In delineating proved oil land on a map, one is guided principally by finished wells, but the underground geologic conditions must also be carefully studied and used as a further guide. The character of the geologic structure is the usual criterion in which much trust is placed, but in some fields the underground geologic structure possesses minor significance, the more important factors being the difference in porosity of the beds, the lenticular character of the sands, both locally and regionally, and the water conditions in the sand. These factors may act singly or in any combination, closely inter-related and of equal or unequal importance. A person must possess a thorough knowledge of the principles governing oil accumulation before he can intelligently delineate proved oil land. The Kern River field in California and the Glenn Pool in Oklahoma are notable examples of accumulations which owe their existence to factors other than geologic structure. In general, both are monoclinal in character.

The factors governing oil accumulation may vary greatly in different fields. In some localities, such as in California and Wyoming, geologic structure may be the principal factor, and because of this, the main outline of proved land will be determined by the locations of producing wells, and the undrilled areas between producing wells will be classified by structure. For instance, the proved acreage, including the drilled land, may be rather easily determined by drawing a line inclosing the producing wells, but where undrilled areas occur, the structure of the oil sand is used as a guide (Fig. 1). The distance from the wells of the line bounding proved acreage will depend on conditions. In California, in localities where the line is determined by development, it is drawn one location from producing wells.

In some Oklahoma fields, geologic structure apparently plays relatively an unimportant role, the accumulations being governed by lenticularity and differences in porosity or texture of the oil sands. An 80-acre tract may have excellent oil wells drilled in its corners, but its central half may be of absolutely no worth when drilled. Several tracts, with which the author is familiar, have been even more misleading. In other parts of the same state, oil is found in synclines.

Where geologic structure is not the controlling factor we certainly

are unwise to draw the limits of proved acreage a great distance from producing wells because knowledge of the other factors is more difficult to obtain previous to drilling, and predictions based on it are thus rendered extremely uncertain.

Figure 1 represents the sub-surface structure of an oil sand in a portion of an Oklahoma oilfield. The structure contours show depths below sea-level of the top of the sand, and the symbols represent the wells at that time producing oil from the contoured sand. The land proved to contain oil or gas is that on top of the structure with no hachures whereas the probable and possible lands are shown by two kinds of hachures.

It will be noted that the proved area does not lie exactly on top of the structure and, in fact, that all three classes of land lie more on the west than on the east side of the fold. This distribution is entirely in accordance with our definitions. The proved land is limited first by development, and next by geologic data, which includes information on the accumulation of oil and gas and the relationship of oil and gas to geologic structure as well as specific data on the character of the fold containing them. In the area represented by the map, the accumulation, as a rule, lay farther down on the west side of north-south folds and farther down on the long axis of folding than on the east side or short axis, respectively. Furthermore, the beds in which these folds occur in this part of Oklahoma were in general monoclinal with a gentle westward dip. This gives short east dips which do not favour accumulations on that side of the fold and long west dips between uplifts which were very favourable as gathering grounds.

Proved Land as Defined by the U.S. Treasury Department.—Although the above definition was proposed for use by the Bureau of Internal Revenue, it became necessary, on account of the so-called "discovery" clause in the Revenue Act of 1918, for the Treasury Department to put into effect a definition even more specific. The following definition is given in Treasury Decision 2956; it is used by the department in determination of the acreage that may be valued on account of the discovery of oil or gas on undeveloped land. "... A proven area for the purpose of this statute shall be presumed to be that portion of the productive sand or zone or reservoir included in a square surface area of 160 acres having as its centre the mouth of a well producing oil or gas in commercial quantities."

The above definition appears to set up 160 acres arbitrarily as the amount of land proved when a new well is brought in, and although we should not condemn any attempt of the Government

to afford the oil operator an easy means of determining quickly the lands for which he may claim a valuation, the faults in the above definition, especially from a geological standpoint, are too obvious to require discussion.

Probable Oil Land.—Probable oil land is that usually adjacent to producing oil wells, from which the projection of underground geologic data, by a preponderance of evidence, indicates the existence of oil in commercial quantities, but leaves some room for doubt.

"Probable" is defined by Webster as "having more evidence for than against; supported by evidence that inclines the mind to believe, but leaves some room for doubt; likely," so that if there is more evidence *for* than *against* obtaining oil in commercial quantities, the land should be placed in the probable class—regardless of its location.

The basis of the definition is two-fold: (1) the inference as to the existence of oil, gained from surface geologic evidence supported by the projection of underground geologic data from an area of known conditions, and (2) the contiguity of the land to productive acreage.

Obviously, this definition depends more upon the examination and balancing of all geologic evidence for and against the existence of oil than does the definition of proved oil land.

The nearness to producing wells is relative; it may possess greater importance in some fields than in others. For instance, in a closely folded region of anticlinal accumulations, land, two locations from a producing well, may be worthless, whereas, in a region of gentle dips with oil accumulations rather consistently occurring in the crests of broad domes and anticlines, land, a mile from the discovery well, may easily be placed in the probable class.

Contiguity to production is, therefore, not the controlling factor, for under some circumstances lands may be "probable" that are located a considerable distance from production. For instance, suppose an oil horizon, known invariably to produce oil wherever encountered under favourable conditions of structure, is determined to lie within reach of the drill, under a favourable structure along the crest of which many seepages occur, but situated several miles from the nearest production. Under these exceptional conditions one would be justified in placing some of the acreage in the probable class, for there seems to be more evidence for than against the existence of oil.

Other examples of probable oil lands are those situated on a well outlined structure, with regular sands, but not having the limits of production defined, those on good structure with several

producing wells, but with more or less irregular sands, and those practically surrounded by producing wells with known irregular sands and where structural conditions may or may not be known.

Possible Oil Land.—Possible oil land is that, usually not adjacent to producing oil wells, which, according to geologic and other natural evidence, such as seepages, may produce oil.

The word " possible " seems too broad, for almost any untested land may *possibly* produce oil ; " prospective " is the term originally employed by the author, but several correspondents have suggested the substitution, and because these definitions are the result of the deliberations of several men—not one—the term " possible " is being suggested.

" Possible," according to Webster, is that which is " not contrary to the nature of things ; free to happen or not. That may be true so far as knowledge tells ; more or less likely from the circumstances known," and " prospective " is defined as " being within consideration, as a future contingency ; relating to the future ; expected."

Possible areas include those not proved and not probable upon which there is any likelihood of obtaining oil in commercial quantities. Some may argue that this class, therefore, embraces too wide a range of possibilities, and that its range of possibilities or prospects is greater than the range of possibilities of probable land. That is not true, however, if the definitions are literally limited according to Webster's definitions and modified by our own restrictions ; proved oil land is certain for all practical purposes ; probable oil land begins with that on which the chances are greater for commercial production than against, and possible oil land ranges from that which has practically no chance to that with an even chance of producing oil in commercial quantities.

The essence of the definition is the distance of the land from production and the fact that the only geologic evidence available for consideration is that furnished by surface indications. Synclines in some regions may be rated as possible ; " spotted " fields will contain much possible land ; in fact, any area, where a majority of chances are against the existence of oil, but where some prospects for oil are found, may be called possible.

Possible and probable oil land is further distinguished from proved land by the lack of a basis for estimating their future production. In the first place, there is no practical certainty that lands in either of these classes will produce oil, whereas, there is a practical certainty that proved land will produce oil. Furthermore, a basis of estimating how much it will produce consists in the

records of nearby wells. No such basis exists for the estimation of the future production of possible oil land; assumptions only can be made on the basis of the lands becoming productive.

Commercially Non-productive Oil Land.—Commercially non-productive oil land is that on which commercially productive wells cannot be drilled at present.

In many fields this definition will not be used extensively, but in such fields as those in California, there are many areas where the presence of oil is practically proved, but the wells are so expensive that they cannot at present be drilled with profit. Probable and possible oil land may also be rated as commercially non-productive, contingent, of course, on the final proof that oil exists there. No land can be placed in this and in any of the other classes at the same time, for if land is proved it will support commercial producers. If the existence of oil is proved but wells cannot be drilled with profit, the land, according to our definition, cannot be placed in the proved class.

The same argument applies to the other two classes, which are differentiated by their prospects of obtaining oil in commercial quantities. If the existence of oil is probable under a tract of land, and the sand is beyond the reach of the drill, the land must be commercially non-productive.

Conclusion.

Land can be classified into the proposed classes usually without great difficulty, and if the boundary lines of different areas are made according to legal sub-divisions, the amount of acreage can be readily computed.

Exceptions undoubtedly will be found, and some cases will be very difficult to settle. For instance, in some places the existence of productive zones or sands below a producing sand may be probable or possible. Different areas may be placed in all four different classes, for some of it may be proved and some may be probable, possible or commercially non-productive. Each sand, therefore, may require a different classification; they must be considered as separate tracts or fields.

The drilling of a gas well on an anticline or dome may cause a difference of opinion as to the oil prospects of the land, and an analysis of the gas may lead one to believe in the existence of oil on the flanks of the fold, whereas, another, without the analysis, would claim that no oil existed in the reservoir. Most of these cases, however, may be settled by a close study of conditions, based

on a comprehensive knowledge of oil accumulation, origin and movement.

Land may change rapidly from one class to another. The drilling of one well may prove an extensive area that previously was probable or possible, or it may serve to place commercially non-productive oil land in the proved class. Water troubles may develop, suddenly causing proved areas to lose much of their value and place them in the probable class, or the price of oil may increase to such an extent that wells may be drilled with profit on land where the existence of oil was previously certain, but which was unprofitable to drill. Known oil-bearing sands, lying below the depth of the drill, and thus commercially non-productive, with improved drilling methods, may later be drilled with profit. In fact, any development that brings forth more evidence may change the classification greatly.

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Current Bibliography.

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The following list of papers and patents is abstracted to the end of May, 1920 :—

Geological.

Egypt. The Oil Fields of.—W. F. Hume. *Pet. Times* **2**, 269, 1919.

Kern River Field of California.—R. N. Ferguson. *Pet. Times* **2**, 634, 1919.

Oil Bearing Formations in Texas.—J. A. Udden. *Oil & Gas Jour.* **18**, No. 25, 80–4 (1919).

Petroleum and Coal.—E. Donath. *Chem. Zeit.* **93**, 497, 1919.

Petroleum. Geologic distillation of.—B. Willis, *Mining & Met.* No. 157, Sect. 10, 1920. *Pet. World* **17**, 108, 1920.

Sunset-Midway Oil Fields, California.—G. S. Rogers. U.S. Geol. Survey. *Profess. Paper* **117**, 1919. *Chem. Abstracts* **14**, 1100, 1920.

Why and Where Oil is Found.—J. C. Yancey. J. H. Eggers Co., New York, 23 pp.

Geographical.

Bituminous Deposits of Esthonia.—*Chemisch Weekblad Mar.* 20, 1920. *Tech. Rev.* **6**, 370, 1920.

Los Naranjos Gushers in Mexico.—*Pet. World* **17**, 68, 1920.

Oil Development in Alberta.—Wilson Bluer. *Oil News* No. 372, 54, 1920.

Oilfields of South America.—W. E. Aughinbaugh. *Pet. Times* **3**, 43, 1920.

Oil in Canadian Western Provinces.—C. N. Pearce. *Pet. Times* **2**, 353–5, 1919.

Peruvian Petroleums (*a*).—Ricardo A. Deustua. *Bol. del. petroleo.* (*Mexico*) **7**, 531, 1919.

Petroleum and Natural Gas in West Virginia.—John Warren Philips & Van Brunt, New York, 14 pp.

Petroleum Possibilities in France.—W. A. Hall. *Pet. Times* **2**, 533, 1919.

Petroleum Resources of Great Britain.—A. C. Veatch. *Oil News*, No. 376, 157, 1920.

Petroleum Resources of the World.—John F. Northrup. *Eng. Mining Jour.* **108**, 953, 1919; **109**, 34, 1920.

Petroliferous Provinces of America.—E. G. Woodruff. *Pet. Times* **3**, 73, 1920.

Reward for Oil Discovery in Australia.—*Hardware & Machinery.* Nov., 1919.

Shale Deposits of U.S. Rich in Oil.—J. J. Jakowsky & F. H. Sibley. *Oil & Gas Jour.* 18, Nos. 23, 58, 60, 62, 64 (1919).

South American Petroleums. Optical investigations on some primary. —E. Longobardi. *Soc. Argentina de ciencias naturales*, Nov. 21, 1916. *Chem. Abstracts* 14, 1604, 1920.

TRINIDAD OIL FIELDS. (Reprint from *Oil, Paint & Drug Reporter*). Important details of Industry. *Pet. Times* **3**, 87, 1920.

WHY AND WHERE OIL IS FOUND.—J. C. Yancey. J. H. Eggers Co., New York, 23 pp.

DRILLING AND FIELD OPERATIONS.

DRILLING AND PRODUCTION IN THE BAKU FIELDS.—A. Knapp. (Amer. Inst. of Min. Engs.) *Pet. World* **17**, 122, 1920.

DRILLING FOR PETROLEUM IN ENGLAND.—*Pet. Times* **3**, 163, 1920.

GOVERNMENT'S OIL WELLS. Review of 1919 operations.—H.M. Petroleum Executive. *Pet. Times* **3**, 85, 1920.

HYDROCARBON GASES. Recovering liquefiable hydrocarbons from.—A. J. Paris, Junr. U.S. Pat. 1,320,168. Oct. 28, 1919.

LOSSES AT OIL WELLS.—*Engineering* **109**, 221, 1920.

MEASURING CASING IN OIL WELLS.—M. H. Soyster & J. H. Dougherty (Californian State Mining Bur.). *Pet. Times* **3**, 115, 1920.

MUD FLUID IN ABANDONING OIL WELLS. Possibilities of.—R. P. McLaughlin. *Pet. Times* **3**, 382, 1920.

OIL FIELD EMULSIONS. J. L. Sherrick.—*J. Ind. Eng. Chem.* **12**, 133, 1920.

PETROLEUM BORE HOLES. Progress Diagrams.—*Engineering* **108**, 321, 1919.

WATER DISPLACEMENT IN OIL AND GAS SANDS.—R. H. Johnson. *Pet. Times* **3**, 251, 1920.

WATER IN OIL WELLS. Sealing off.—B. B. Grunwald. U.S. Pat. 1,318,076. Oct. 7, 1919.

SEALING OF FORMATIONS IN AN OIL WELL BY MUD FLUID.—J. B. Case. *Pet. Times* **3**, 254, 1920.

PIPE LINES, TRANSPORT AND STORAGE.

BULK STORAGE METHODS APPLIED TO DISTRIBUTION. *Pet. Times* **3**, 465, 1920.

CONCRETE OIL TANK. (55,000 bits.)—*Tech. Rev.* **6**, 436, 1920.

FUEL OIL. Tentative regulations for storage and use of. Report of National Fire Prevention Assoc., New York.—*Chem. & Met. Eng.* Dec. 24–31, 781–785, 1919.

KERB PETROL IN LONDON.—*Oil News*, No. 375, 125, 1920.

LIQUID FUEL RESERVOIR. Lining with Cement and Concrete Blocks.—*Indian Engineering*, 31st Jan., 1920. *Tech. Rev.* **6**, 437, 1920.

LOADING REGULATIONS.—U.S. Bureau of Explosives issued by the American Petroleum Institute. Circular 190 cancelling Circulars 180 and 184.

MATERIAL FOR WALLS OF MINERAL OIL RESERVOIRS.—A. Macbeth. U.S. Pat. 1,325,448, 1919.

OIL AND GAS STORAGE TANKS. Heat reflecting properties of colours applied to.—H. A. Gardner. Paint Manufact. Assoc. U.S.A. Circular No. 44. *Jour. Soc. Chem. Ind.* 39, 91A, 1920.

OIL FUEL. Supplying ships at sea.—*Engineering* **108**, 75, 1919.

———— Tanks, Pneumareator Deph. Gauge.—*Engineering* **108**, 454, 1919.

OIL TANKERS IN 1914 AND 1919.—*Pet. Times* **3**, 99, 1920.

TANK WAGGON AND STORAGE TANK CHARTS.—E. G. Wheeler. *J. Soc. Chem. Ind.* **39**, 141R, 1920.

Refinery Technique.

Acid Sludge obtained in refining petroleum and shale oils. Utilization of Asphaltic base.—C. Baskerville. *Jour. Ind. Eng. Chem.* **12**, 30, 1920.

Atlantic Refining Co. Plant. Amer. Chem. Soc. Industrial Excursions. —*Chem. & Met. Eng.* Oct. 15, 488–502, 1919.

Boilers. Operating oil fired—efficiently.—R. Sibley & C. H. Delany. *Elec. World*, 74, 1100, 1919.

Carbon Black. Its properties and uses.—G. St. J. Perrott & R. Thiessen. *J. Ind. & Eng. Chem.* **12**, 324, 1920.

Carbon Dioxide in Flue Gases when Burning Oil.—*Power*, Jan. 20, 1920. *Tech. Rev.* **6**, 370, 1920.

Corrosion of Petroleum Condenser Tubes.—Michael Freund. *Chem. Zeit.* **43**, 587, 1919.

Deodorizing and Clarifying Volatile Organic Bodies. Process of and apparatus for.—W. A. Hall. Brit. Pat. 109,077, 1917.

Desulphurization of Oils. Improvements relating to.—Otto P. Amend & Josiah H. Macy. Brit. Pat. 14,405, 1892.

Distilling Petroleum.—H. A. Frasch. U.S. Pat. 1,318,657. Oct. 14, 1919.

Distillation of Liquid Hydrocarbons. Corthesy's Gas Produce Syndicate—Description of Invention.—*Pet. World* **17**, 62, 1920.

Distilling Petroleum Oils.—R. H. Brownlee. U.S. Pat. 1,320,376 Nov. 4, 1919.

Distilling Petroleum Oils.—F. E. van Thilberg. U.S. Pat. 1,326,230, 1919.

Distillation and Rectification.—L. Gay. *Chim. et Ind.* **3**, 157, 1920. *J. Soc. Chem. Ind.* **39**, 287A, 1920.

Electric Dehydration of Oil. Abstract from *Electrical Review (Chicago)*. —*Chem. Trade Jour.* **66**, 204, 1920.

Electrochemical Treatment of Hydrocarbon Oils.—L. B. Cherry. U.S. Pat. 1,327,023, 1920.

Emulsifying Oil Substances.—J. A. DeCew. U.S. Pat. 1,317,617. Sept. 30, 1919.

Fullers' Earth. Preparation of—for treatment of Mineral Oils.—W. C. Phalen. *Chem. & Met. Eng.* **21**, 469, 1919.

Fullers' Earth. Report of.—Committee of the Society of Cotton Products Analysts. *Cotton Oil Press* 3, No. 3, 79–80. July, 1919.

Heat Economy in Chemical Plants.—Harold Nielsen. *Chem. Trade Jour.*, Nov. 29, 1919.

Hydrocarbons. Continuous and uniform treatment of—with sulphurous acid.—*Allgem. Ges. für Chem. Ind. Berlin.* Brit. Pat. 114,845, 1918; 133,962, 1919.

Hydrocarbon Oil Distillates. Process of condensing and treating.—R. Fleming. U.S. Pat. 1,325,668, 1919.

Lampblack, by product from Oil Gas Manufacture, a readily marketted domestic fuel.—E. L. Hall. *Am. Gas Eng. Jour.*, 112, 77, 1920.

Liquid Hydrocarbons. Refining.—A. E. Dunstan. Brit. Pat. 139,233, 1918.

Mineral Oils. Needed of extended research in the Petroleum Industry.—V. H. Manning. *Chem. & Met. Eng.* Dec. 10–17, 727–728, 1919.

MINERAL OILS. The distillation of Petroliferous products.—F. Brodas. *Annal. Falsif.* Nov.–Dec., 1919, 346.

NEW PROCESS FOR PRODUCTION OF LIGHT FUELS.—A. J. & W. F. Paris. U.S. Nat. Adv. Com. for Aeronautics Rept., 42.

OIL FIELD EMULSIONS. J. L. Sherrick. *J. Ind. Eng. Chem.* **12**, 133, 1920.

OILS. Extraction of—by volatile solvents. A. W. MacIlwaine & G. F. Holdcroft. Brit. Pat. 136,870, 1918.

PETROLEUM AND THE LIKE. Method and apparatus for distilling.—Cleveland Trust Co., Cleveland, Ohio, U.S.A. Brit. Pat. 134,567.

PETROLEUM IN BULK. Handling of—at Thames Haven.—N. A. Anfilogoff. *J. Soc. Chem. Ind.* **39**, 138T, 1920.

PETROL FIRES. Prevention and Extinction.—*Engineering* **108**, 316, 1919.

PURIFYING PETROLEUM OILS and other liquids.—W. G. Laird. U.S. Pat. 1,320,396. Nov. 4, 1919.

REFRIGERATING PLANT EFFICIENCY DATA.—V. J. Azbe. *Power*, Oct. 21, 1919.

RECTIFICATION BY ADIABATIC CONDENSATION WITHOUT EXPANSION.—E. Chenard. *Bull. Soc. Chim.* (*IV.*) **25**, 546–552 (1919).

RECTIFICATION OF HYDROCARBON.—De Bataafsche Petroleum Maatschappy & J. H. C. de Brey. Brit. Pat. 123,522, 30th Oct., 1918.

RECTIFYING HYDROCARBONS or other Liquids.—E. A. Barbet. U.S. Pat. 1,317,319. Oct. 21, 1919.

SOLVENT EXTRACTION.—H. J. Pooley. Chemical Engineering lecture, Manchester College of Technology, *Chem. Trade Jour.* **66**, 103, 1920.

SULFONIC ACIDS FROM MINERAL OIL SLUDGE.—R. E. Divine. U.S. Pat. 1,330,624, 1920.

STEEL SMOKE-STACKS. Preservation of.—H. L. Clemmer & J. E. Heckel. *Drugs, Oils & Paints* **35**, 290, 1920.

TEMPERATURE CONTROL in modern Petroleum Refining (*b*).—C. B. Kennedye. *Oil News* 8, II, 13, 1919.

WASTE LYES AND WASHINGS FROM THE REFINING OF PETROLEUM.—F. Schutz. *Petroleum* **14**, 654, 1919.

WASTE PRODUCTS IN THE PETROLEUM INDUSTRY. Working up of (*B*).—E. W. Albrecht. *Chem. Zeit.* 44, 282, 1920. (*A*) and (*B*) *J. Soc. Chem. Ind.* **39**, 358A, 1920.

NATURAL GAS AND ITS COMPONENTS.

CARBON, HYDROGEN AND METHANE. Equilibrium between.—H. F. Coward & S. P. Wilson. *Chem. Soc. Trans.* **115**, 1380, 1919.

FLAME. Propagation of—in complex gaseous mixtures.—W. Payman. Part I. *Chem. Soc. Trans.* **115**, 1436, 1919; Part II. *Chem. Soc. Trans.* **115**, 1446, 1919; Part III. *Chem. Soc. Trans.* **115**, 1454, 1919.

GASOLINE FROM NATURAL GAS.—J. B. Gardner & H. C. Cooper. U.S. Pat. 1,332,290, 1920.

GASOLINE FROM NATURAL GAS. Recent developments in absorption process for recovering.—W. P. Dykema. *U.S. Bur. of Mines, Bull.* 176.

HELIUM. Petroleum Investigations and the production of.—Van H. Manning. *U.S. Bur. of Mines, Bulletin* 178 *C.* (being part of advance sheets of *Bull.* 178). *Engineering* **109**, 124, 1920.

HYDROCARBON GASES. Recovering liquefiable hydrocarbons from.—A. J. Paris, Junr. U.S. Pat. 1,320,168. Oct. 28, 1919.

HYDROCARBON VAPOURS. Separating aqueous and—from Gases. A. J. Paris, Junr. U.S. Pat. 1,320,167. Oct. 28, 1919.

IGNITION TEMPERATURES OF GASES. Soap bubble method.—A. G. White & T. W. Price. *Chem. Soc. Trans.* **115**, 1248, 1919.

METHANE.—*Chem. Soc. Trans.* Dec., 1380–1387 (1919).

NATURAL GAS FOR POWER IN GAS ENGINES.—*Gas Age*, **44**, 493, 1919.

BENZINE AND MOTOR FUELS.

BENZINE AND BENZINE Mixtures as Motor Fuel. Use of.—I. C. Mackie. *Can. Chem Jour.* **3**, 295–7 (1919).

BENZOL AS MOTOR FUEL.—*Chem. Age* **2**, 2, 1920.

FUEL. Gasoline—like.—C. Ellis. U.S. Pat. 1,318,060–1,318,061. Oct. 7, 1919.

FUEL. Motor, Comparisons of Alcohol, Benzole and Petrol.—*Engineering* **108**, 690, 1919.

FUELS FOR MOTOR VEHICLES.—*Engineering* **109**, 85, 1920.

GASOLINE Apparatus for obtaining—from Petroleum and other oils.—A. A. Stapp. U.S. Pats. 1,324,212 and 1,324,213, 1919.

——— BY ABSORPTION PROCESS.—*U.S. Bureau of Mines, Tech. paper* 232. W. P. Dykema & R. O'Neal.

GASOLINE (CLEANING) FILTERS.—H. A. Hills. U.S. Pat. 1,328,044/5/6, 1920.

——— Composition of some Asiatic.—G. Chavanne & L. J. Simon. *Compt. rend.* **169**, 285 (1919).

GASOLINE FROM CASING HEAD GAS. Apparatus for recovering.—W. R. McGinnis. U.S. Pat. 1,328,680, 1920.

GASOLINE FROM HYDROCARBON GASES. Process for obtaining.—H. C. Cooper. U.S. Pat. 1,323,837, 1919.

GASOLINE FROM NATURAL GAS. Apparatus for separating.—A. B. Cross. U.S. Pat. 1,327,906, 1920.

GASOLINE FROM NATURAL GAS.—E. S. Merriam. Can. Pat. 193,204. Oct. 14, 1919.

GASOLINE. Improving.—A. M. McAfee. U.S. Pat. 1,326,072 and 1,326,073, 1919.

GASOLINE in Natural Gas. Experiments on Alberta Gas.—D. B. Dowling. *Can. Dept. Mines, Geol. Survey. Summary Rept.* 1918, 170–420 (1919).

GASOLINE. Process of manufacturing.—A. D. Smith, U.S. Pat. 1,324,075, 1919.

GASOLINE SPECIFICATIONS. Changes in American.—*Oil and Gas J.* **18**, No. 26, 62, 1919.

GASOLINE. Use of the critical temperature of solution in Aniline—for complete analysis of.—G. Chavanne & L. J. Simon. *Compt. rend.* **169**, 70, 185 (1919).

GASOLINE VAPOUR. Flow of.—J. Rey. *Compt. rend.* **168**, 1092, 1919.

GERMAN AIRCRAFT PETROL. Analysis of.—(*La Nature*, Nov. 22, 1919). *Technical Review*, **6**, No. 1, 41, 1920.

LIQUID FUEL.—U.S. Ind. Alcohol Co. Brit. Pat. 133,709, 1919.

MOTOR FUELS. Future supplies of.—Harold Moore. *Chem. Age* **2**, 16, 1920.

MOTOR GASOLINE. Properties, testing, specifications.—E. W. Dean. *U.S. Bur. of Mines, Tech. Paper* 214.

MOTOR SPIRIT.—E. W. Stevens. Brit. Pat. 135,514, 1919.

MOTOR SPIRIT PRODUCTION. The Cherry Process.—L. B. Cherry. *Pet. Times* **3**, 383, 1920.

PETROL. Production of.—F. Tinker. Brit. Pat. 135,015, 1918.

PETROLS, etc. Apparatus for continuous fractional distillation. E. A. Barbet. Brit. Pat. 117,615. 22nd June, 1918.

PETROLEUM SPIRIT, etc. Elimination of the danger of ignition of electrically charged.—D. Holde, *Ber. deut. Pharm. Ges.* **29**, 569, 1919; Abstract, *Jour. Soc. Chem. Ind.* **39**, 96A, 1920.

KEROSENE.

GAS OIL AND INTERMEDIATE OIL.

LUBRICATING OILS AND LUBRICANTS.

LUBRICANT FOR STEAM CYLINDERS.—L. B. Lockhart. U.S. Pat. 1,330,882, 1920.

LUBRICATING OIL.—H. M. Wells & J. E. Southcombe. U.S. Pat. 1,319,129. Oct. 21, 1919.

LUBRICATING OIL. Purifying used.—F. W. Kennedy. U.S. Pat. 1,318,086. Oct. 7, 1919.

LUBRICATING OIL. Regeneration of used.—Rialland. *Ann. Fals.* **12**, 217, 1919.

LUBRICATING OIL SYSTEMS FOR TURBINES.—J. E. Schmeltzer & B. G. Fernald. *Tech. Rev.* **6**, 445, 1920.

LUBRICATING OILS AND LUBRICATION.—*Engineering* 108, 520, 725, 755, 758, 759, 788, 1919.

LUBRICATING OILS. Examination of.—*Engineering*, May 14, 1920.

LUBRICATING OILS. Examination of.—*Engineering* **109**, 653, 1920.

LUBRICATING OILS. Production of—from Asphaltic Materials.—F. Seidenschnur & C. Kottnitz. Ger. Pat. 305,105, 1916; 307,166, 1916.

LUBRICATING OILS. Purifying used.—W. von Sperl. Ger. Pat. 314,175, 1918.

LUBRICATION OF BALL BEARINGS.—H. R. Trotter. *J. Amer. Soc. Mech. Eng.* 1919.

LUBRICATION. Technical and Economic aspects of.—F. Frank. *Zeit. ang. Chem.* **32**, 374, 1919. Abstract, *J. Soc. Chem. Ind.* **39**, 148A, 1920.

LUBRICATION.—T. E. Stanton, L. Archbutt & J. E. Southcombe. *Engineering* **108**, 758, 1919.

LUBRICATION. Theory and Practice of. The "Germ" Process.—H. M. Wells & J. E. Southcombe. *J. Soc. Chem. Ind.* **39**, 51T, 1920.

LUBRICATION.—*Times Eng. Suppl.*, Dec., 1919.

LUBRICANTS.—H. M. Wells & J. E. Southcombe. Brit. Pat. 130,377. Feb. 5, 1918.

LUBRICANTS IN GERMANY.—*Chem. Trade Jour.* **66**, 135, 1920.

OILINESS & LUBRICATION.—R. M. Deeley. *Engineering* **108**, 788, 1919.

SAPONIFIED LUBRICANTS (Lubricating Greases).—A. Kraus. Seife **3**, 602, 1919.

SOLID LUBRICANTS. Dept. of Scientific and Industrial Research. Bulletin No. 4, H.M. Stationery Office.—*Engineering* **109**, 321, 1920.

Fuel Oil (Boiler Fuel).

Fuel. Economical utilization of.—A. Joulot. *Techn. Moderne.* Dec., 522–526, 1919.

Fuel Oil.—C. B. Forward. Can. Pat. 193,453. Oct. 28, 1919.

Fuel Oil.—*Elec. Times*, Dec. 25, 1919.

Fuel Oils.—F. Tinker. Brit. Pat. 130,699. Mar. 18, 1918.

Heavy Oil Engines. Applic. of liquid fuel to.—A. J. Wilson. *Engineering* **109**, 19, 1920.

Les Combustibles Liquides, etc.—A. Guiselin. Paris: Dunod & Pinat, 548 pp.; Review: *J. Chim. Phys.* **17**, 522, 1919.

Liquid Fuel. Applications of.—*Chem. Age* 2, 2, 1920.

Liquid Fuel. Application of—to Heavy Oil Engines—*Engineering* **109**, 19, 1920.

Liquid Fuel.—W. Ker Wilson, *Mech. World*, Feb. 6 and 27, 1920. *Tech. Rev.* **6**, 329, 1920.

Oil Fuel Firing. Some notes on.—J. L. Chaloner. *Pet. Times* **3**, 401, 1920.

Oil Fuel from Well to Consumer.—J. H. Williams. (Institute of Marine Engineers.) *Pet. Times* **3**, 113, 1920.

Oil Fuel in the Navy.—*Engineering* **108**, 860, 1919.

Oil Versus Coal as Fuel for Central Stations.—C. H. Delany. *Elec. World*, 74, 928, 1919.

Relative Costs of Oil Fuel and Coal. (American Experiments.)—*Pet. Times* **3**, 227, 1920.

Diesel Oil and Engines.

Diesel Engine. Its Fuel and its uses. (U.S. Bur. of Mines paper.)—Herbert Haas. *Pet. Times* **3**, 45, 1920.

Diesel Engines. The wear of.—*Engineering* 109, 416, 1920.

Liquid Fuel. Application of—to Heavy Oil Engines.—*Engineering* **109**, 19, 1920.

Oil Fuels for Diesel Engines, Research.—*Engineering* **108**, 621, 1919.

Thermal Efficiency in Diesel and other internal combustion Engines. Limits of.—Dugald Clerk. *Engineering* 108, 77, 1919. *Engineer* 128, 40, 1919.

Plant and Machinery.

Absorption Refrigerating Machines.—H. J. Macintire. *Power*, Nov. 11, 1919.

Apparatus for Separating Oil and gas as they come from wells.—A. M. Ballard. U.S. Pat. 1,327,691, 1920.

Distillation. Continuous Fractional.—A. M. O'Brien. Brit. Pat. 140,140, 1918.

Fractional Distillation. Apparatus for.—E. A. R. Chenard. Brit. Pat. 130,992, 1918 (Appl. 19, 318/19).

Heat Exchangers.—G. Bastien. *Mem. Soc. Ing. Civils de France*, 72, 183, 1919.

Heating, Piping and Settling Apparatus for Mineral Oils.—W. P. Strother. U.S. Pat. 1,326,618, 1919.

OIL TANK. Moving a large—by flotation. *Iron Trade Rev.*, 19th Feb., 1920. *Tech. Rev.* **6**, 445, 1920.

PETROLEUM DISTILLING APPARATUS.—U. S. Jenkins. U.S. Pat. 1,321,749. Nov. 11, 1919.

PETROLEUM OILS IN VACUUM. Apparatus for distilling.—A. von Groeling. U.S. Pat. 1,327,184, 1920.

PETROLEUM STILL.—W. Meischke Smith. U.S. Pat. 1,327,247, 1920.

STILL FOR PETROLEUM OILS.—H. Henderson. U.S. Pat. 1,335,438, Mar. 30.

STILL HEAD for light oil fractionation. Constant temperature.—F. M. Washburn. *Jour. Ind. Eng. Chem.* 12, 73, 1920.

STILL HEADS OF VARIOUS TYPES. Comparative investigation of the efficiency of.—J. Friedrichs. *Zeit. ang. Chem.* **32**, 340–344 (1919).

TOPPING PLANTS.—*Bulletin* 162, *U.S. Bur. of Mines.* "Removal of the Lighter Hydrocarbons from Petroleum by continuous distillation as practised in California." J. M. Wadsworth.

TESTING, ANALYSIS AND APPARATUS.

AROMATIC HYDROCARBONS IN PETROL (*A*). Methods of Estimation of.—D. Florentin & H. Vandenbergh. *Bull. Soc. Chim.* 27, 204, 1920.

ASPHALT. Rapid method of determining Hard.—J. Tausz & A. Lüttgen. *Petroleum* **14**, 653, 1919.

BENZENE. Effect of pressure and of dissolved air and water on the Melting point of.—T. W. Richards, E. K. Carver & W. S. Schumb. *J. Amer. Chem. Soc.* **41**, 2019, 1919.

CALORIFIC VALUE OF OILS. Testing Methods.—*Engineering* **108**, 586, 1919.

CALORIFIC VALUE of Volatile Liquid Mixtures. Determination of—in Bomb.—G. Barsky. *J. Ind. Eng. Chem.* **12**, 77, 1920.

CERESIN. Algebraic method for the detection of adulteration of—with paraffin (*A*).—H. Smelkus. *Chem. Zeit.* **44**, 273, 1920.

DISTILLING COLUMN (Laboratory) and method of measuring its efficiency.—M. Robert. *Ann. Chim. Analyst.* Dec. 15, 372–377, 1919.

ELECTRIC HEATER FOR THE COAL TAR NAPHTHA DISTILLATION TEST.—J. B. Hill & R. B. Chillas. *J. Ind. Eng. Chem.* **12**, 280, 1920.

FORMOLITE REACTION (*d*).—L. G. Radcliffe. Perf. Ess. Oil Rec. **11**, 48, 1920. (*a*), (*b*), (*c*), (*d*), *J. Soc. Chem. Ind.* **39**, 259A, 1920.

FUEL OILS, especially Benzine, characterizing, by the Picric Acid number.—J. Tauss & E. Schnabel. *Chem. Zeit.* **43**, 726, 1919. *Chem. Abstracts* **14**, 1207, 1920.

GASOLINE IN CASING GAS. Apparatus for determining amount of.—D. L. Newton. 1,330,490, 1920.

GASOLINE IN NATURAL GAS. Quantitative Estimation.—K. Kling. *Metan*, **1**, 3, 1917.

HYDROCARBONS. Analysis of—by the aid of bacteria.—J. Tausz & M. Peter. *Chem. Zentr.* **91**, II, 264, 1920.

MACMICHAEL TORSIONAL VISCOMETER.—W. H. Herschel. *J. Ind. Eng. Chem.* **12**, 282, 1920.

MINERAL OILS. Freezing point of.—E. Lantos. *Chem. Zeit.* **43**, 853, 1919. Abstract, *Jour. Soc. Chem. Ind.* 39, 96A, 1920.

MIXING APPARATUS.—R. R. Gray. Brit. Pat. 138,286, 1919.

MOTOR GASOLINE TESTING. Facts about (*d*).—G. A. Kramer. *Petroleum* **8**, 20, 1919.

MOTOR SPIRIT AND ITS PROPERTIES. Methods of testing (U.S. Bureau of Mines).—E. W. Dean. *Pet. Times* **2**, 482, 1919.

NEW METHODS OF TESTING LUBRICANTS.—German Technical Lubrication Committee. *Tech. Rev.* **6**, 362, 1920.

PARAFFINS IN COMMERCIAL TOLUOL. Estimation of.—E. Lewis. H. G. Colman. *Jour. Soc. Chem. Ind.* **39**, 143, 1920.

PETROLEUM REFINING. Instruments used in Testing.—*Scient. Amer. Suppl.* **88**, No. 2285, 268–269. 1919.

PETROLEUM PRODUCTS. Laboratory distillation of.—F. Bordas. *Ann. Falsif.* **12**, 346, 1919. *J. Soc. Chem. Ind.* **39**, 220A, 1920.

RECTIFICATION. Glass Column.—W. Elsner. *Chem. Zeit.* Jan. 3, 11–12, 1920.

REFRACTOMETER IN CHEMICAL INDUSTRY. The use of.—P. J. Fryer. *Chem. Age* **2**, 326, 1920.

SAMPLING. Some problems and fallacies of.—W. L. Baillie. *Chem. Trade Jour.* **66**, 333, 1920.

SOFTENING OF PLASTIC MATERIALS determined by the WIDNEY RESILIOMETER.—Alan Speedy. *Jour. Soc. Chem. Ind.* 39, 18T, 1920.

SULPHUR IN OILS. New Method for the determination of.—C. E. Waters. *J. Ind. Eng. Chem.* **12**, 482, 1920.

SULPHUR IN PETROLEUM OILS. Determination of.—A. W. Christie & C. S. Bisson. *J. Ind. Eng. Chem.* **12**, 171, 1920.

TAR VALUE OF MINERAL OIL. Estimation of.—A. Krammer. *Petroleum*, 14, 1025, 1919.

TENTATIVE TEST FOR VISCOSITY OF LUBRICANTS. Loss on Heating of Oil and Asphaltic Compounds.—U.S. Bur. Standards. *Proc. Am. Soc. Testing Materials* **19**, 1919.

TESTING ILLUMINATING OIL SUBSTITUTES.—A. Krieger. *Jour. Gasbel.* 61,220–1 (1919).

TOLUENE. Criteria of the degree of purity of commercial.—J. S. Lumsden. *Chem. Soc. Trans.* **115**, 1366, 1919.

TOLUENE. The critical Solution temperatures of a ternary mixture as a criterion of purity of.—K. J. P. Orton & D. C. Jones. *Jour. Chem. Soc.* **115**, 1055–70 (1919).

VAPOUR TENSION. New Instrument for measuring.—Harold Moore. *Chem. Age* **2**, 66, 1920; *Chem. Age* **2**, 96, 1920.

VISCOMETER, FOR GASOLINE.—W. H. Herschell. U.S. Bur. Standards, *Proc. Am. Soc. Test. Mat.* **19**, 6, 76–86 (1919). *Chem. Abstracts* **14**, 1036, 1920.

VISCOMETER for measuring viscosity and fluidity.—G. Baume & H. Vigneron. *Ann. Chim. Analyst.* Dec. 15, 379–383, 1919.

VISCOMETER.—G. Baume & H. Vigeron. *Ann. Chim. Analyst* **1**, 379, 1919.

VISCOSITY of Hydrocarbon Mixtures. Method of calculating.—W. F. Espy. *Petroleum (Chicago)* **8**, 27–28, 1919.

CRACKING.

ALUMINIUM CHLORIDE RESIDUES. Utilizing.—L. S. Abbott. U.S. Pat. 1,332,018, 1920.

BREAKING DOWN HEAVIER INTO LIGHTER HYDROCARBONS.—F. A. Korman. U.S. Pat. 1,332,849, 1920.

CARBON REMOVING MEANS (in Cracking Hydrocarbons).—W. F. Rittman & C. B. Dutton. U.S. Pat. 1,320,852, 1920.

COMPRESSED OIL GAS. Note on the Oil from.—J. C. Mansukham & J. J. Sudborough. *J. Ind. Inst. Sci.*, Pt. 6, 73, 1920.

CONVERSION OF PETROLEUM HYDROCARBONS INTO PRODUCTS OF LOWER BOILING POINTS.—R. Fleming. U.S. Pat. 1,324,766, 1919.

CRACKING AND DISTILLING PETROLEUM OILS.—R. F. Bacon, B. T. Brooks & C. W. Clark. U.S. Pat. 1,334,731, Mar. 23.

CRACKING AND DISTILLING PETROLEUM OILS.—H. W. Jones, U.S. Pat. 1,336,357, Apr. 6.

CRACKING AND DISTILLING PETROLEUM OILS.—F. E. Wellman. U.S. Pats. 1,335,767–8–9–71–2–3, Apr. 6.

CRACKING AND DISTILLING PETROLEUM OILS.—F. E. Wellman & F. H. Sibley. U.S. Pat. 1,335,770, Apr. 6.

CRACKING HYDROCARBON OILS.—J. H. Adams. U.S. Pat. 1,320,726. Nov. 4, 1919.

CRACKING HYDROCARBON OILS. Apparatus for.—J. H. Adams. U.S. Pat. 1,320,727. Nov. 4, 1919.

CRACKING HYDROCARBON OILS. Furnace and pipe system for.—A. R. Jones. U.S. Pat. 1,328,522, 1920.

CRACKING HYDROCARBON OILS to obtain illuminating gases.—M. C. Whitaker & W. F. Rittman. U.S. Pat. 1,327,001, 1920.

CRACKING HYDROCARBON OILS.—L. A. Dubbs. U.S. Pat. 1,319,053. Oct. 21, 1919.

CRACKING HYDROCARBON OILS.—W. F. Rittman. U.S. Pat. 1,330,008, 1920.

CRACKING HYDROCARBONS.—Ned. Lichte Olie Maat. Brit. Pat. 135,197, 1919.

CRACKING HYDROCARBONS.—R. Fleming. Brit. Pat. 135,854, 1919.

CRACKING PETROLEUM.—Cleveland Trust Co. Brit. Pat. 134,567, 1918.

CRACKING PETROLEUM.—W. M. Cross. U.S. Pat. 1,326,851, 1919.

CRACKING PETROLEUM.—P. Hubbard. U.S. Pat. 1,326,056, 1919.

CRACKING PETROLEUM OILS. Apparatus for.—J. H. Adams. U.S. Pat. 1,320,354. Oct. 28, 1919.

CRACKING PETROLEUM OILS. Apparatus for.—B. Andrews & W. C. Averill, Jr. U.S. Pat. 1,319,828. Oct. 28, 1919.

CRACKING PETROLEUM.—Y. Nakagawa. *Jour. Chem. Ind. Japan*, 22, 394–400 (1919).

CRACKING PETROLEUM.—F. C. Ruff. U.S. Pat. 1,325,582, 1919.

CRACKING PETROLEUM OILS.—B. Andrews & W. C. Averill. U.S. Pat. 1,329,739.

DEHYDROGENATION OF HYDROCARBONS by means of Palladium Black.—J. Tausz & N. von Putnoky. Ber. **52**, 1573–1583, 1919.

HEATING OIL-CRACKING PIPES. Furnace for.—F. E. Wellman. U.S. Pat. 1,335,774, Apr. 6.

HYDROCARBON. Apparatus for Cracking.—T. E. Yaley. U.S. Pat. 1,329,450, 1920.

HYDROCARBONS. Conversion of.—R. Fleming. U.S. Pat. 1,324,766, 1919.

———— Process and apparatus for treating.—R. R. Rosenbaum. U.S. Pat. 1,324,983, 1919.

HYDROCARBONS. Treatment of liquid—for the transformation thereof.—N. C. & C. E. Cassall & B. H. Gerrans. Brit. Pat. 117,087, 1916.

HYDROCARBON OILS.—C. F. Forwood & J. G. Taplay. Brit. Pat. 133,059, 1916.

LOW BOILING OIL. Manufacture of—from higher boiling Petroleum or related oils.—E. B. Cobb. U.S. Pats. 1,322,878 and 1,322,762, 1919.

MINERAL OIL OF HIGH BOILING POINT. Process of converting—into products of low boiling point.—R. Koetschau. Waldheim, Germany. U.S. Pat. 1,325,299, 1919.

OIL CRACKING STILLS. Furnace for.—F. E. Wellman. U.S. Pat. 1,328,468, 1920.

OIL CRACKING STILL.—J. L. Gray. U.S. Pat. 1,331,909, 1920.

PETROLEUM. Process of and apparatus for cracking.—F. C. Ruff. U.S. Pat. 1,325,582, 1919.

PETROLEUM SPIRIT (BENZINE). Breaking down high boiling hydrocarbons into.—F. Bergins. Ger. Pat. 304,348, 1913.

AROMATIC HYDROCARBONS FROM PETROLEUM.

AROMATIC HYDROCARBONS FROM MINERAL OILS.—F. C. Ruff. U.S. Pat. 1,319,420. Oct. 21, 1919.

AROMATIC HYDROCARBONS FROM PETROLEUM OILS.—N. C. & C. E. Cassall & B. H. Gerrans. U.S. Pat. 1,330,844, 1920.

MINERAL OILS. Removal of Aromatic Hydrocarbons.—J. Tausz. *J. praky. Chem.*, Nov. 276–280, 1919. Abstract.—*J. Soc. Chem. Ind.* **39**, 147A, 1920.

SHALE AND SHALE OIL.

DISTILLING OIL FROM SHALE.—J. A McCaskell. U.S. Pat. 1,317,514. Sept. 30, 1919.

NORFOLK OIL SHALE INDUSTRY.—*Pet. Times* **3**, 213, 1920.

OIL FROM OIL BEARING SHALE. Apparatus for distilling.—H. R. Straight. U.S. Pat. 1,323,204, 1919.

OIL SHALES OF COLORADO.—V. C. Anderson. *Pet. Times* **3**, 225, 1920.

OIL SHALE INDUSTRY. Possibilities of.—H. M. Roeschlaub. *Engineering & Mining Jour.* 108, No. 14, 572–576 (1919).

SHALE OILS. Process for obtaining—in rotary carbonizing retorts.—Konigl. Bau-und Berg-direktion, Stuttgart and Zeller und Gmelin. Eislingen. Ger. Pat. 303,803. 1st Mar., 1917.

SHALES. Recovery of nitrogen contained in Oil Shales.—L. Simpson. *Chem. & Met. Eng.* Jan. 7, 20–22, 1920.

LIGNITES AND COAL AND THEIR PRODUCTS.

ASPHALT AND COAL. Origin of.—J. Marcusson. *Chem. Zeit.* **44**, 43, 1920.

BENZINE (PETROL) FROM LIGNITE TAR. Production of—by cracking.—F. Fischer & W. Schneider. *Chem. Zentr.* **90**, IV, 1074, 1919. *J. Soc. Chem. Ind.* **39**, 288A, 1920.

BITUMEN OF BOHEMIAN LIGNITE (*b*).—W. Schneider. *Chem. Zentr.* **90**, IV, 1072, 1919.

CARBONACEOUS MATERIAL. Apparatus for distillation of solid.—C. D. Burney. Brit. Pat. 136,585 (Appls. 14, 176 and 19,177, 1918).

CARBONACEOUS MATERIAL. Apparatus for distilling.—Burney. Brit. Pat. 14,176 & 19,177. 1918.

CARBONIZATION OF FUEL BY VERTICAL COKE OVENS, ETC.—Davies. Brit. Pat. 21,239, 1918.

COAL DISTILLATION at low temperatures.—*Engineering* **109**, 217, 1919.

COAL. Researches on.—Amé Pictet, Series IX, 249.

COKING OF COAL TAR PITCH.—A. Fischer. *J. Gasbel.* **62**, 510, 1919.

DISTILLING AND CARBONIZING PITCH.—F. M. Perkin. Brit. Pat. 129,091, 1918.

DISTILLATION, ETC. OF CARBONACEOUS MATERIALS.—W. E. Davis. Brit. Pat. 131,105. July 3, 1919.

FUEL OIL AND LAMP OIL (SOLAR) FROM COAL (*g*) Production of.—W. Gluud. *Chem. Zentr.* **90**, IV, 883, 1919. (*c*), (*d*), (*e*), (*f*) and (*g*) *J. Soc. Chem. Ind.* **39**, 223A, 1920.

ICHTHYOL. Chemical constituents of the bituminous tar oils rich in sulphur.—H. Scheibler. Ber. **52**, 1903–1910. 1919.

LIGHT PETROLEUM AND PARAFFIN FROM COAL (*e*).—F. Fischer & W. Gluud. *Chem. Zentr.* **90**, IV, 881, 1919.

LIGNITE. Separation of—into different groups of substances, their characters and behaviour on dry distillation.—W. Schneider. *Chem. Zentr.*, 91, II, 99, 1920. *J. Soc. Chem. Ind.* **39**, 324A, 1920.

LIGNITE SOLUBLE IN ALKALI from the Niederlausitz district (*c*).—W. Schneider & O. Jantsch. *Chem. Zentr.* **90**, IV, 1972–1919.

LIGNITES. (*a*) Production of low temperature tar from—and its use as a source of viscous oils.—W. Schneider. *Chem. Zentr.* **90**, IV, 935, 1919.

——— (*b*) A technically produced low temperature tar from.—W. Schneider & H. Tropsch. *Chem. Zentr.* **90**, IV, 937, 1919; (*a*) and (*b*) *J. Soc. Chem. Ind.* **39**, 222A, 1920.

——— (*c*) Behaviour of low temperature tar from bituminous and non-bituminous—when distilled under ordinary pressure.—W. Schneider. *Chem. Zentr.* **90**, IV, 937, 1919.

——— TAR OILS. (*d*) Production of viscous oils from non-viscous—by heating in an autoclave.—W. Schneider. *Chem. Zentr.* **90**, IV, 940, 1919.

LOW TEMPERATURE CARBONISATION (*a*).—F. Fischer & W. Gluud. *Ber.* **53**, 250, 1920.

LOW TEMPERATURE CARBONISATION. Investigation of the suitability of German Coal for.—F. Fischer & W. Gluud. 3 parts. *Chem. Zentr.* **90**, IV, 1919. *J. Soc. Chem. Ind.* **39**, 258A, 1920.

LOW TEMPERATURE CARBONIZATION.—Tern. Ber. **52**, 1836, 1919.

LOW TEMPERATURE destructive distillation of Coal.—Swinburne. Brit. Pat. 261, 1919.

LOW TEMPERATURE DISTILLATION OF FUEL.—Merz & McLellan, Michie and Weeks. Brit. Pat. 136,868. 1918.

LOW TEMPERATURE DISTILLATION. The solution of.—Nat. H. Freeman. *Pet. Times* **3**, 543, 1920.

LOW TEMPERATURE TAR FROM LIGNITE. Characteristic difference between —and other Tars.—F. Fischer & W. Schneider. *Chem. Zentr.* **90**, IV, 883, 1919. *J. Soc. Chem. Ind.* **39**, 224A, 1920.

LIQUID PARAFFINS OF LAMP OIL FRACTION OF LOW TEMPERATURE COAL TAR (*f*).—F. Fischer & W. Gluud. *Chem. Zentr.* **90**, IV, 882, 1919.

MONTAN WAX. Data of the saponification value of.—H. Salvaterra. *Chem. Zeit.* **44**, 129, 1920. *J. Soc. Chem. Ind.* **39**, 220A, 1920.

MONTAN WAX.—G. Meyerheim. *Seifenfabr.* **39**, 365, 1919.

PARAFFIN WAX IN LANCASHIRE COAL.—(Manchester Geological & Mining

Society, Nov., 1919). F. S. Sinnatt & M. Barash. *Colliery Guardian*, Nov. 14, 1919.

PETROLEUM SPIRIT FROM LIGNITE TAR BY CRACKING.—F. Fischer & W. Schneider. *Gas Abhandl. zur Kenntnis dur Kohle*, 1917, II, 36.

PITCH. Combustion of.—Rowntree & Co. (Ltd.) & F. G. Fryer. Brit. Pat. 135,886, 1918.

PITCH. Process for vaporizing and gasifying.—W. Herrmann. Ger. Pat. 314,996, 1918.

SHALES & COALS. Distillation of.—D. E. Day. U.S. Pat. 1,323,681. 2nd Dec., 1919.

TAR PREPARATIONS IN ROAD CONSTRUCTION.—*Gas Age* **45**, 21, 1920.

BIBLIOGRAPHY AND STATISTICS.

BRITISH MINERAL OIL. A treatise on.—Ormandy, Dunstan, Perkin, Campbell & Seabrook. Edited by Greene. Charles Griffin & Co., London; pp. 233, Review. *J. Soc. Chem. Ind.* **39**, 101R, 1920.

ECONOMICS OF THE PETROLEUM INDUSTRY.—R. S. Dickie. Lecture at Imperial College of Science and Technology. *Pet. Times* **3**, 305, 1920.

HANDBOOK OF PETROLEUM.—Roy Cross. Kansas City Testing Lab. 496 pp.

MINERAL OIL. Annual Report of Society of Chemical Industry, 1920.—A. E. Dunstan.

MINERAL OIL. Import and Export Statistics, U.S.A.—*Oil Paint & Drug Reporter*. Pet. Sect. **97**, No. 7, 13, 1920.

MINERAL OIL.—*Jour. Soc. Chem. Ind.* **39**, 3R.

OIL AND PETROLEUM MANUAL. 375 pages.—W. R. Skinner, London, Publisher and Editor.

PETROLEUM and Allied Substances in 1916. Bibliography of.—E. H. Burroughs. *U.S. Bur. of Mines, Bull.* 165.

PETROLEUM AND THE WAR.—Sir John Cadman, Lecture at Royal Institution. *Report Oil News*, No. 380, 13/3/20.

PETROLEUM HANDBOOK.—S. O. Andros. Shaw Publishing Co., Chicago, 206 pp. Review—G. W. Gray. *J. Ind. Eng. Chem.* 12, 516, 1920.

OIL PITCH, ASPHALT AND BITUMEN.

ASPHALTIC MACADAM (BITUMINOUS) ROADS.—*Engineering* **108**, 707, 737, 792, 1919.

ASPHALT (Matita). Products obtained by the dry distillation of.—C. Nicolescu-Otin. *Bull. Acad. Roumaine*, 5, 129, 1916. *J. Soc. Chem. Ind.* **39**, 219A, 1920.

ASPHALT. Origin of.—J. Marcusson. *Chem. Zeit.* Jan. 13, 43–44, 1920.

MODERN ROADS.—H. P. Boulnois. London, 1919. Edward Arnold, pp. 302.

OILING ROADS. "BITUMINOUS PENETRATION SURFACES" by A. B. Manson. *Can. Eng.*, 11th Mar., 1920. *Tech. Rev.* **6**, 439, 1920.

PETROLEUM PITCH. Destructive distillation of.—K. Nomi. Japan. Brit. Pat. 114,617. 11th Feb., 1918.

REFINING ASPHALT.—R. R. Rosenbaum. U.S. Pat. 1,332,359, 1920.

Paraffin Wax, Ceresin and Ozokerite, Vaseline.

Montan Wax. Behaviour of—towards ozone.—F. Fischer & H. Tropsch. *Chem. Zentr.* **90**, IV, 847, 1919.

Paraffin Residue. Producing Cakes of Solid Crude.—Szekely. Brit. Pat. 18,727, 1919.

Paraffin. Natural and changing properties of (*c*).—S. Ljubowski. *Seif. Zeit.*, 46, 429, 1919.

Paraffin. Thermal Expansion of and solution of.—W. von Piotrowski. *Zeit. physik. Chim.* **93**, 596–606 (1919).

Paraffin Wax (*B*). Influence of high temperature on.—H. Burstin & W. Jakubowiez. *Petroleum* **15**, 189, 1920. (*A*) and (*B*)—*J. Soc. Chem. Ind.* 39, 325A, 1920.

Paraffin Wax. Technique of crystallisation in the manufacture of.—*Petroleum (Berlin)* **14**, 1281, 1919. *J. Soc. Chem. Ind.* **39**, 220A, 1920.

Petroleum Jelly Substitute.—*Rut. Akt. Ges.* Brit. Pat. 134,528, 1919.

Waxes. Extracts from Bulletin of Imperial Institute.—*Chemical Trade Journal* **66**, 34, 1920.

Origin of Petroleum.

Origin of Petroleum. Distillation of Sodium Stearate, and Oleate under reduced pressure.—Amé Pictet & Jacques Potok *Helvetia Chim. Acta.* **2**, 501–10 (1919).

Petroleum. Genesis of.—C. F. Mabery. *J. Amer. Chem. Soc.* **41**, 1690–1697; 1919.

Petroleum. Origin of.—E. Engler, Abstract from "Nature." *Chem. Trade Jour.* **66**, 134, 1920.

Viscosity.

Mineral Oils. Congealing of Mineral Oils.—E. Lantos. *Chem. Zeit.* Dec. 6, 853, 1919.

Reducing Viscosity of Oil. Means for.—E. C. Elliott. Brit. Pat. 25644, 1919.

Viscosity. Fluid Motion and viscosity.—W. L. Cowley. *Engineering*, Jan. 23, 101–102, 1920.

Viscosity. Nature of.—Nicolas Flamel. *Optician*, Jan. 16, 1920.

Viscosity of hydrocarbon mixtures. Method of calculating.—W. F. Espy. *Petroleum (Chicago)* **8**, 25–28, 1919.

Viscosity of Organic Colloids.—E. Rothlin. Biochem. *Zeits* **98**, 34–92, 1919.

General and Colloid Chemistry of Petroleum and Products.

Aqueous Emulsions of Oil and their separation.—I. Mescicki & K. Kling. *Metan* **1**, 121, 1917.

Fatty Acids by oxidation of Paraffin Wax.—D. Fanto & Co. Brit. Pat. 132,027, 1919.

Increasing the Optically Active Constituents of Bitumen by Means of Ozone (*c*).—Jenö Tausz. *Chem. Zeit.*, 43, 225, 1919. (*a*), (*b*), (*c*), (*d*), (*e*), *Chemical Abstracts* **14**, 1034, 5, 6, 1920.

OIL EMULSIONS. Apparatus for treatment of.—C. W. McKibben. U.S. Pat. 1,327,835, 1920.

OIL WATER EMULSIONS.—A. W. McCoy, H. R. Shudel & E. A. Trager. *Mining & Met.*, 1919, 3168.

PARAFFIN. Oxidation of.—C. Kelber. *Ber.* 53, 66, 1920. *J. Soc. Chem. Ind.* **39**, 220A, 1920.

PETROLEUM. Possibility of synthetic.—G. Brum. *Giorm. Chim. Indust.* 1919.

RESIDUE ACIDS of Petroleum and Paraffin refining. Results of the investigation of the.—E. Kolbe. *Petroleum* **12**, 173.

RESINOUS PRODUCT FROM ISOPRENE OR SIMILAR HYDROCARBONS.—H. V. Dunham. U.S. Pat. 1,324,649, 1919.

SYNTHETIC PRODUCTION OF FATS. Results from Petroleum.—*Chem. Age* **2**, 114, 1920.

MISCELLANEOUS.

OIL GAS MANUFACTURE. Experiments in Connection with.—J. D. Ruys. *Chem. Weekblad.* **16**, 746, 1919. Abstract, *J. Soc. Chem. Ind.* 39, 146 and 1919.